BLM LIBRARY
88064930

INSPECTION COPY

Please do not remove

Rio Blanco Oil Shale Company

MODULAR DEVELOPMENT PHASE MONITORING REPORT FOUR

VOLUME 1 OF 2

December 1978 – May 1979

Mid-Year Report

U. S. DEPARTMENT OF INTERIOR
OIL SHALE
ENVIRONMENTAL ADVISORY PANEL
Denver Federal Center
SEP 25 1979

Gulf Oil Corporation / Standard Oil Company (Indiana)
A General Partnership

9725 East Hampden Avenue, Denver, Colorado 80231

TN
859
.C64
R56
Dec.78-
May 79
v.1
c.2

8806 4930

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

TN
859
.C64
R56
Dec 78 -
May 79
v.1
c.2

RIO BLANCO OIL SHALE COMPANY
MODULAR DEVELOPMENT PHASE
MONITORING REPORT 4

December 1978 - May 1979

MID-YEAR REPORT

Prepared by:
RIO BLANCO OIL SHALE COMPANY
DENVER, COLORADO

August 31, 1979

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Hank Ash, Chairman
OSEAP

DATE: September 11, 1979

FROM : Acting Area Oil Shale Supervisor

SUBJECT: Rio Blanco Oil Shale Company
Modular Development Phase Monitoring Report Four

Enclosed for your office and panel use is a copy of Rio Blanco Oil Shale Company's Monitoring Report Four (December 1978 through May 1979). This report is the mid-year monitoring report.

Please call if you have any questions concerning the enclosed report.

James W. Hager

James W. Hager

Encs. Vols. 1 & 2

U. S. DEPARTMENT OF INTERIOR
OIL SHALE
ENVIRONMENTAL ADVISORY PANEL
Denver Federal Center

SEP 25 1979

5010-110

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

TABLE OF CONTENTS

Section	Title	Page
1	INTRODUCTION	1
2	ATMOSPHERIC STUDIES	5
2.1	Air Quality	8
2.2	Meteorology	15
2.3	Visibility	19
2.4	Noise	20
2.5	Summary and Conclusions	25
3	TERRESTRIAL STUDIES	27
3.1	Vegetation, Range, and Browse	30
3.2	Fauna	36
3.3	Summary and Conclusions	44
4	AQUATIC STUDIES	47
4.1	Abiotic Components	51
4.2	Biotic Components	58
4.3	Summary and Conclusions	78
5	HYDROLOGY STUDIES	81
5.1	Surface Water	84
5.2	Ground Water	98
5.3	Operational Monitoring	136
5.4	Summary and Conclusions	136
6	SPECIAL STUDIES	166
6.1	Toxicology	167
6.2	Revegetation	168
6.3	Subsidence	169
6.4	Sage Grouse	170
6.5	Raw Ore Leachate Sampling	171
7	ECOLOGICAL INTERACTIONS	172
7.1	Snow Cover and Spring Runoff	174
7.2	Temporary Surface Discharge of Dewatering Water	176
7.3	Human Activity on or Adjacent to the Tract	178
8	SUMMARY	179

LIST OF APPENDICES

APPENDIX	TITLE
2-1	Air Quality Data
2-1.1	Sites 1 and 3 Gaseous Constituents
2-1.2	Particulate Data - Sites 1, 2, and 3
2-2	Meteorological Data
2-2.1	Site 1 Meteorological Data
2-2.2	Sites 2 and 3 Meteorological Data
2-2.3	Precipitation Data - Sites 1, 2, and 3
3-1	Vegetation Data
3-1.1	Browse Data
4-1	Abiotic Data
4-1.1	Physical Data
4-1.2	Water Quality Data
4-2	Biotic Data
4-2.1	Periphyton Data
4-2.1a	Periphyton Enumeration and Biomass Data
4-2.1b	Occurrence of Periphyton Taxa by Sampling Stations
4-2.1c	Periphyton Density Data
4-2.1d	Biomass Analysis Data
4-2.2	Macroinvertebrate Data
4-2.2a	Macroinvertebrate Enumeration Data
4-2.2b	Occurrence of Macroinvertebrate Species at Each Sampling Station
4-2.2c	Macroinvertebrate Density Data
5-1	Surface Water Data
5-1.1	USGS Surface Gaging Station Data - Statistical Summaries
5-1.2	USGS Surface Gaging Station Data - Individual Analyses
5-1.3	USGS Sediment Data - Water Year 1978
5-2	Groundwater Data
5-2.1	Alluvial Aquifer Water Quality - Individual Analyses
5-2.2	Alluvial Aquifer Water Quality - Individual Statistical Summaries
5-2.3	Alluvial Aquifer Water Quality - Combined Statistical Summaries

LIST OF APPENDICES (Cont.)

APPENDIX	TITLE
5-2.4	Deep Oil Shale Aquifer Water Quality - Individual Analyses
5-2.5	Deep Oil Shale Aquifer Water Quality - Individual Statistical Summaries
5-2.6	Statistics Equations
5-3	Operational
5-3.1	Erosion and Sedimentation Data and Representative Cross-Sections
5-3.2	Surface Water
5-3.3	Alluvial Aquifer
6-3	Subsidence Monuments
6-3.1	Subsidence Monuments Locations

SECTION 1
INTRODUCTION

In 1969, the U.S. Department of the Interior initiated planning for a prototype oil shale leasing program that eventually resulted in Gulf Oil Corporation and Standard Oil Company (Indiana) acquiring an oil shale lease for Tract C-a in the Piceance Creek basin of northwest Colorado in 1974. These two companies are now operating the tract under a general partnership called the Rio Blanco Oil Shale Company (RBOSC).

Since its inception in 1974, the RBOSC has been conducting extensive environmental data collection programs. Between October 1974 and September 1976, two years of baseline data were gathered. From September 1976 through August 1977, interim environmental data were collected during the period in which RBOSC had suspended tract development activities. In August 1977, RBOSC launched their Modular Development Phase (MDP) Environmental Monitoring Program. The first report of MDP environmental activities (September - November 1977) was published in February 1977. Subsequent reports were published in September 1978 and March 1979. The current report represents RBOSC's fourth MDP Monitoring Report, and covers the period from December 1978 - May 1979.

The RBOSC MDP Environmental Monitoring Program is designed to collect air quality, meteorology, terrestrial ecology, aquatic ecology, and hydrology data. Monitoring program designs are based on analysis of baseline and interim studies data, an assessment of probable developmental impacts, and recommendations from the Area Oil Shale Office (AOSO). The monitoring conducted during this reporting period was done according to the RBOSC Modular Development Phase Environmental Monitoring Program Scope of Work dated August 17, 1977, as modified by permission of the AOSO. This scope of work reflects the environmental monitoring philosophy set forth in RBOSC's Detailed Development Plan (DDP). On April 26, 1979, Revion 5.2 of the Environmental Monitoring Program, dated March 30, 1979, was approved by the AOSO with 17 conditions. Hereafter, the RBOSC monitoring program will be conducted in accordance with the March 30, 1979 scope of work, as approved and subsequently modified by the AOSO.

In November 1978 RBOSC began to establish an in-house environmental staff. By April 1979 this staff had been largely assembled. Therefore major responsibility for monitoring program activities during the reporting period rested with RBOSC personnel. Continuity of the program was assured by two means: 1) acquisition of several former consultants familiar with the program, and 2) training of RBOSC personnel by consultants previously responsibile for the work. Several consultants were used in various capacities during this period. They include: NUS Corporation (data handling, training, water quality analyses, general consulting), Wright Water Engineers (Environmental Hydrology), Morrison-Knudsen (Operational Hydrology), MARIAH Associates (Aquatic studies), USGS (Surface water gaging station program). Section 4.0 - Aquatic Studies was prepared by MARIAH Associates; Section 5.0 - Hydrology Studies was prepared by Wright Water Engineers. Section 5.0 includes the USGS water data.

Data collected during MDP monitoring studies are reported semi-annually, in a mid-year and a year-end report. Monitoring Report 4, the second mid-year data report, presents the data collected for the six-month period, a summary of the winter and spring data, brief discussions of the data, comparisons of the winter and spring 1978 data with previous data where applicable, and notations on impacts which may have been caused by initial development activities, if any.

Objectives of the monitoring program are presented herein. Methods are presented only if they differ from the methods presented in previous RBOSC MDP Monitoring Reports, or if clarification is required. Some programs were scheduled to start after May 30 according to the approved scope of work. The descriptions of these programs will appear in the year-end report. A new section entitled "Special Studies" has been incorporated into this report. This section discusses studies that are conducted periodically or opportunistically as necessary and provide a format for presenting data that might otherwise be obscured. Volume 1 of this report contains eight sections as follows:

Section 1 - Introduction
Section 2 - Atmospheric Studies
Section 3 - Terrestrial Studies
Section 4 - Aquatic Studies
Section 5 - Hydrology Studies
Section 6 - Special Studies
Section 7 - Ecological Interactions
Section 8 - Summary

Volume 2 contains the following data appendices:

2-1 Air Quality Data
2-2 Meteorological Data
3-2 Vegetation Data
4-1 Abiotic Data
4-2 Biotic Data
5-1 Surface Water Data
5-2 Ground Water Data
5-3 Operational Data
6-3 Subsidence Data

SECTION 2
ATMOSPHERIC STUDIES

The Tract C-a atmospheric studies program consists of two elements - (1) measurements of total suspended particulate matter and certain chemical compounds, and (2) measurements of selected meteorological parameters. The monitoring locations were originally established to measure the ambient air quality generally upwind and somewhat removed from the expected tract development, and at points where tract developments might have an effect on the air quality. Simultaneous meteorological measurements are being made to allow evaluations of air quality changes and for prediction of the dispersion of emissions from tract development.

Air quality and meteorological data have been obtained from monitoring instruments located on or near Tract C-a since February 1975. The first two years of data collection make up the baseline data set. Data from the baseline period were obtained at four locations around the tract. Following the baseline period, an interim data acquisition program was established to cover an interval during which the tract development lease conditions were modified and partially suspended. During the interim period (February through August 1977), a single air quality and meteorological monitoring station was operated to maintain data continuity.

The current program is part of the Modular Development Phase (MDP). The level of activity on the tract, principally construction work, has increased significantly during the MDP period. The monitoring program has also been increased in order to measure possible effects on the ambient air quality. Two of the sites that had been deactivated for the interim period were refitted with meteorological instrumentation and put back online during the MDP first quarter. In addition, one of the reactivated meteorological sites is gradually being refitted with a set of air quality instrumentation. This should be completed by September 1979 (Table 2-1).

Table 2-1. Air Studies Monitoring Parameters and Program Schedule

Parameter	Location	Start Date	Frequency
Sulfur Dioxide	Site 1	Sept. 1977	Continuously
	Site 3	Jan. 1978	Continuously
	Site 5	March 1980	Not defined yet
Nitrogen Oxides	Site 1	Sept. 1977	Continuously
	Site 3	Sept. 1979	Continuously
Nitric Oxide	Site 1	Sept. 1977	Continuously
	Site 3	Sept. 1979	Continuously
Hydrogen Sulfide	Site 1	Nov. 1977	Continuously
	Site 3	Jan. 1978	Continuously
Carbon Monoxide	Site 1	Oct. 1977	Continuously
	Site 3	Sept. 1979	Continuously
Hydrocarbons**	Site 1	Sept. 1977	Continuously
Ozone	Site 1	Sept. 1977	Continuously
	Site 3	Nov. 1977	Continuously
Particulates	Sites 1, 2, 3	Dec. 1977	Every 3rd day
	Site 6**	Dec. 1977	Every 3rd day
Wind direction (10m)	Sites 1, 2, 3	Sept. 1977	Continuously
Wind direction (60m)	Site 1	Sept. 1977	Continuously
Wind speed (10m)	Sites 1, 2, 3	Sept. 1977	Continuously
Wind speed (60m)	Site 1	Sept. 1977	Continuously
Wind sigma (10m)	Site 1	Sept. 1977	Continuously
Ambient temperature (10m)	Sites 1, 2, 3	Sept. 1977	Continuously
Temperature differential (10-60m)	Site 1	Sept. 1977	Continuously
Precipitation	Sites 1, 2, 3 & other selected locations	Oct. 1977	By event
Snow depth and accumulation	Sites 1, 2, 3	Nov. 1978	By event
Solar radiation	Site 1	Sept. 1977	Continuously
Dewpoint (10m)	Site 1	July 1978	Continuously
Visibility	Visibility Shelter	Spring 1978	Semi-annually
Noise	16 locations on tract	Jan. 1978	Quarterly

** discontinued by agreement with AOSS

2.1 AIR QUALITY

Air quality monitoring is being conducted on and near Tract C-a to measure the concentrations of certain pollutants which may be emitted by tract operations. The ambient air quality monitoring network consists of two locations where gaseous constituents are measured (Sites 1 and 3) and three locations where particulate concentrations are measured (Sites 1, 2, and 3). These sites are illustrated on Map 1 (See map pocket). Sites 1 and 2 generally measure background ambient air quality, while Site 3 is located in a broad gulch that may have some air quality changes due to dispersion under downvalley flow from the main development area in the center of the tract.

All of the air quality data, with the exception of the particulate data, is collected on automatic monitoring equipment and recorded on digital computer tape and backup strip charts by a data acquisition system. The data on the digital tape are averaged into hourly values. High volume samplers are used to collect 24-hour samples of particulate data every third day at three sites.

A Spring visibility study, in cooperation with Tract C-b, has been included in the air studies program. An addition has been made to this study by measuring the visual range with a telephotometer as well as with the traditional photometric technique. These data will allow comparisons to be made between the two measurement techniques. However, the Spring visibility study was not completed during the reporting period. The data and results will be included in the year-end report.

One instrument that has been the source of many problems is the SO_2 analyzer at Site 1. A new EPA-certified instrument was ordered during this reporting period as a replacement. It will be put on line soon after the end of this reporting period (late June). Air quality data taken during the sixth and seventh quarters of the MDP program are presented in Appendices 2-1.1 (gaseous constituents) and 2-1.2 (total suspended particulates) and discussed in the following pages.

A. Sulfur Dioxide

1. Objectives

The objective of monitoring for sulfur dioxide is to establish the ambient air concentration prior to and during tract development. The existing sulfur dioxide levels and their associated environmental effects can be compared to future environmental changes that may be related to any increase in the concentration of sulfur dioxide.

2. Methods

The methods followed for collection of sulfur dioxide data were described in RBOSC MDP Monitoring Report 2 and are not repeated herein.

3. Results and Discussion

Unfortunately, the SO_2 monitor at Site 1 was not properly operational for most of this data period, and the SO_2 monitor at Site 3 was not operational for part of this data period. EPA-certified SO_2 monitors are being installed to replace the existing instrumentation at these sites, which will solve this problem. In any event, few measurements above the threshold of detection were anticipated during this period, since no additional activity or retort burning has occurred. Valid data that were recorded confirm these expectations, with maximum SO_2 concentrations below the threshold of detection at Site 1 and 0.12 ppm at Site 3 (Appendix 2-1.1).

B. Hydrogen Sulfide

1. Objectives

The objective of monitoring hydrogen sulfide in the ambient air on the tract is to establish the background value. Tract development, which will involve recovery of sulfur-bearing organics, may release hydrogen

sulfide into the ambient air. Concentrations of this constituent in the future may be compared to pre-development conditions to assess environmental impacts.

2. Methods

The methods for collection of hydrogen sulfide data were described in RBOSC MDP Monitoring Report 2 and are not repeated herein.

3. Results and Discussion

Since the same instruments used to monitor sulfur dioxide are also used to monitor hydrogen sulfide, relatively poor data recovery occurred during this data period. Steps are being taken to correct this problem. There has been one relatively small local source of hydrogen sulfide during this monitoring period -- surface discharge of underground water. Consequently, minor concentrations of hydrogen sulfide were expected, primarily at Site 3 during stable conditions. The data collected support this hypothesis, with maximum concentrations below the threshold of detection at Site 1 and 0.14 ppm at Site 3 (Appendix 2-1.1).

C. Nitrogen Oxides

1. Objectives

Nitrogen oxides are monitored to establish the existing natural background levels prior to major tract development and operation. Tract operations will involve substantial combustion with the possible generation of nitrogen oxides. Nitric oxide in the presence of sunlight and hydrocarbons may be a mechanism for smog production. These data may prove useful in correlating future visibility changes with pollutant concentration.

2. Methods

The methods followed for collection of nitrogen oxides data were described in RBOSC MDP Monitoring Report 2 and are not repeated herein.

3. Results and Discussion

The concentrations of nitrogen oxides were slightly greater than the reliable instrument threshold for only a few hours during the monitoring period. The highest hourly average concentrations for nitrogen oxides and nitric oxide were 0.020 and 0.012 ppm, respectively (Appendix 2-1.1).

Despite these excursions, the average concentration of both NO_x and NO during this six-month period is less than the instrument threshold. This is consistent with the average concentrations found during the baseline and interim data periods.

D. Carbon Monoxide

1. Objectives

Carbon monoxide is monitored to establish the ambient air concentration of this constituent prior to and during tract development activities. Vehicular use and fuel combustion during tract development may result in the emission of carbon monoxide in the tract area.

2. Methods

The methods followed for collection of carbon monoxide data were described in RBOSC MDP Monitoring Report 2 and are not repeated herein.

3. Results and Discussion

No measurements of carbon monoxide were reported above the reliable threshold of the instrument. Much of the time the output of the instrument

was above the threshold, but this was due to the detector, which produces a mean output signal with predominantly positive noise in the absence of a sample. This was confirmed by comparing the weekly zero checks with the ambient readings of the instrument. In all cases, there was no significant difference between the instrument zero and the ambient measurement. Consequently, no carbon monoxide values above the threshold of the instrument are reported in the data set. The mean carbon monoxide concentrations during the baseline period at both sites were also below the reliable threshold of detection of 1.0 ppm (Appendix 2-1.1).

E. Ozone

1. Objectives

Ozone monitoring is conducted to establish the ambient air concentration of this constituent prior to and during tract development and operation. The potential emissions of nitrogen oxides coupled with hydrocarbons and strong sunlight may produce photochemical reactions in the future in the tract area.

2. Methods

The methods followed for collection of ozone data were described in RBOSC MDP Monitoring Report 2 and are not repeated herein.

3. Results and Discussion

Ozone data were recorded for the entire six-month period at Site 1 and Site 3. The range of ozone concentrations was 0.029 to 0.071 ppm at Site 1 and 0.008 to 0.070 ppm at Site 3 (Appendix 2-1.1). The primary hourly NAAQS of 0.12 ppm was not exceeded during the period at either site.

A very strong diurnal variation with a daytime maximum occurred at Site 3, with a much weaker diurnal cycle at Site 1. This pattern is similar

to that found during the previous year's data (See Monitoring Report 3). Ozone concentrations at Site 3 were almost always lower than at Site 1 -- typically the Site 3 concentration would be slightly lower during the day and much lower at night.

F. Particulates

1. Objectives

The objective of atmospheric particulate monitoring is to establish the natural background concentration and the effects of construction in the modular development phase of tract operations.

2. Methods

The total suspended particulate load in the ambient air is determined by the federal reference method utilizing high volume sampling. Suspended particulate measurements were made every fourth day and all sites were placed on the same date schedule in late March 1978. After December 1, 1978, the sampling frequency was increased to once every third day (Table 2-1). There are three sites where particulate data are taken: Sites 1 and 2, which are generally upwind of the construction area; and Site 3, which may be exposed to particulates generated on the tract access roadway (unpaved and approximately 100 yards from Site 3) as well as particulates generated at the construction area under certain valley flow conditions. The particulates generated by the tract access road should decrease after paving in late June 1979, thereby allowing Site 3 to better represent the effects of tract development on the particulate concentrations in the future.

3. Results and Discussion

Table 2-2 presents the geometric mean and highest concentrations of total suspended particulate matter measured at the four sites during the monitoring period. Generally, higher values occurred simultaneously at all stations (Appendix 2-1.2).

Table 2.2. Geometric Mean and Maximum of Suspended Particulates (ug/m^3) December 1978 - May 1979

	Site 1	Site 2	Site 3
Sixth Quarter MDP			
Geometric Mean	4	4	8
Maximum	8	12	65
Seventh Quarter MDP			
Geometric Mean	8	9	19
Maximum	34	33	94

2.2 METEOROLOGY

Meteorological parameters are monitored to provide information on the general climate of the Rio Blanco Oil Shale Company (RBOSC) Tract C-a and to provide a basis for estimating the potential impact of emissions that will result from tract development and operation. Three meteorological sites have been in operation during the MDP (Table 2-1), as illustrated in Map 1 (See map pocket). Meteorological data recorded during the reporting period are presented in Appendix 2-2.

A. Temperature and Stability

1. Objectives

Ambient air temperature provides basic information on monthly and year-to-year variability of climatic conditions at the C-a tract. The measured vertical temperature differential within the lowest layers of the atmosphere can be utilized to determine the stability of the atmosphere. The stability has a profound effect on the dispersion of emissions into the atmosphere that may occur as a result of tract development and operation.

2. Methods

The methods followed for collection of temperature data was described in RBOSC MDP Monitoring Report 3 and are not repeated herein.

3. Results and Discussion

Temperatures at the site had a large range during this data period, which is characteristic of continental climates. The temperature range at Site 1 10 m level was -24.6 to 20.7 C; at Site 1 60 m level, -24.5 to 19.9 C; at Site 2 -26.3 to 21.4 C; and at Site 3, -29.6 to 23.3 C. The temperature data at Site 3 show the influence of the gulch in increasing the temperature range (Appendices 2-2.1 and 2-2.2).

B. Dewpoint

1. Objectives

Dewpoint data, collected since late July 1978, is used in the evaluation of potential cooling system alternatives. The data are more directly useable than relative humidity data, which had been collected onsite for the same purposes during the baseline period and from December 1977 to late July 1978. Relative humidity can be determined from concurrent dewpoint and temperature measurements.

2. Methods

The methods followed for collection of dewpoint data were described in RBOSC MDP Monitoring Report 3 and are not repeated herein.

3. Results and Discussion

Generally, low dewpoints were recorded during this period, as expected in a semi-arid climate. Dewpoints ranged from a low of -30.0 C to a high of 8.6 C (Appendix 2-2.1).

C. Wind Speed and Wind Direction

1. Objectives

The wind speed and wind direction influence atmospheric dispersion. Measurement of the frequency of occurrence of wind speed and wind direction classes can be used in interpreting air quality data.

2. Methods

The methods followed for collection of wind data were described in RBOSC MDP Monitoring Report 3 and are not repeated herein.

3. Results and Discussion

Westerly winds prevailed at Sites 1 and 2 during the period. At Site 3, there was a strong tendency for the wind to be oriented along the axis of the gulch (southwest or northeast). See Appendices 2-2.1 and 2-2.2.

D. Precipitation

1. Objectives

Precipitation is recorded to provide data on the scavenging effects of rain and snowfall on air quality. The moisture content of the ground surface is important in plant growth and revegetation efforts, and may also influence wind erosion.

2. Methods

The methods followed for collection of these data were described in RBOSC MDP Report 2 and are not repeated herein.

3. Results and Discussion

Precipitation data from the several measuring methods are included in the data appendix (Appendix 2-2.3). There are differences in the reported precipitation between the gauges installed at each site but good agreement among sites for a particular gauge type. Although the wedge gauges generally have better exposure, the weighing bucket gauges have better collection and retention efficiency and are therefore considered more accurate. The weighing bucket gauges at Sites 1 and 2 recorded 9.59 and 8.31 inches of precipitation, respectively, during the six-month data period. These are considered the most representative precipitation data at the site.

E. Solar Radiation

1. Objective

Solar radiation is monitored to acquire a data base useful in interpreting air quality data.

2. Methods

The methods followed for collection of solar radiation data were described in RBOSC MDP Monitoring Report 3 and are not repeated herein.

3. Results and Discussion

The majority of the days during the monitoring period was clear with high solar radiation values, typical of a high altitude site with a dry climate. Values are reported in Appendix 2-2.1.

2.3 VISIBILITY

Documentation of visibility in the Piceance Creek Basin is a cooperative study conducted by the Rio Blanco Oil Shale Company and the C-b Shale Oil Venture.

1. Objectives

The objectives of this program are to document the visibility in the area of the Piceance Creek Basin and identify trends or variations in visibility which may be evident during the monitoring program. The results of this program will provide visibility data aginst which past and future data may be compared and with which concurrent meteorological and air quality data may be incorporated for further evaluation and consideration.

2. Methods

Two methods are being employed in the documentation of basin-wide visibility during the Spring study. A photometric method incorporates techniques identical to those utilized during the baseline study and described in RBOSC MDP Monitoring Report 1. A second method which has been newly instituted uses a telephotometer to derive visual ranges. The results of the two methods will be compared at the end of the study. Data are being collected every sixth day along four views during the Spring season. The Fall study has not been finalized as yet.

3. Results and Discussion

The Spring visibility study was conducted during April, May and June of 1979. Since the study was not completed during the period covered by this report, the results will be presented along with the Fall visibility study in the year-end report.

2.4 NOISE

Development activities on Tract C-a will result in increased noise levels in the area. In order to assess the potential effects of these increased noise levels, it will be necessary to identify the sources of the noise and the intensity of noise levels at various distances from these sources. The RBOSC noise survey is designed to provide these data.

1. Objectives

Regulations regarding allowable noise levels have been promulgated for the safety and well being of humans. None of the existing regulations apply to effects of noise on wildlife, although some research has been conducted in this area (EPA 1971, Effects of noise on wildlife and other animals, Memphis State University). The objectives of the environmental noise program are to:

- Provide a data base on relative noise levels at various distances from sources on the tract
- Provide data for use by wildlife biologists in assessing the overall impacts of tract development on wildlife behavior and use of the study area.

2. Methods

In order to acquire the necessary noise level measurements, sound level readings are taken once each quarter at strategic monitoring sites around the mine development area. During the period of study, two noise surveys were made. Noise measurements were taken at 15 monitoring sites on February 19, and at 16 monitoring sites on May 22. The monitoring sites were arranged in a configuration of concentric circles at various distances from the area of mine activity out to the borders of Tract C-a, as illustrated in Map 1 (See map pocket) and described in Table 2-3.

Table 2-3. Locations of Environmental Noise Monitoring Sites, Tract C-a

Site Number	Locations/Descriptions
1	Top of knoll N.E. of Hunting Camp, E. of road down to Corral Gulch
2	South side of site access road, 20 ft S.W. of "Hill" signs
3	N.E. corner of intersection of Airplane Ridge Road and tank access road
4	South side of Corral Gulch Road at fence corner slightly past power line
5	100 ft S.E. from well CE-707, on line between survey point and Headframe
6	Northwest of Well TO-2 outside of fence, 10 ft W. of survey point
7	North side of Corral Gulch Road at Well G-S 4-5 on top of road cut
8	West side of Wolf Ridge road on small knoll directly across from entrance to Well G-S 6 and trailer camp
9	North side of fenced area at Well TO-1 near entrance
10	South side of Box Elder Gulch Road at N.E. fence corners for Well AM-3
11	North side of Corral Gulch Road at turn-around area, across from U.S.G.S. stream gauging station
12	South side of road to Met. Site #1, 0.1 mile from power line crossing and S.W. corner of well G-S 1
13	North side of Wolf Ridge Road, N.E. corner of road to Well G-S 10
14	South side of Wolf Ridge Road at Tract C-a boundary line
15	East side of road, 0.15 mile north of Met. Site #2 access road
16	North of County Road 24 at intersection of Wolf Ridge Road
A	Approximately 30 ft east of main shaft Headframe

One other reading was taken in close proximity to the headframe for an indication of highest noise production.

The methods followed in the collection of noise data were described in RBOSC MDP Monitoring Report 3 and are not repeated herein.

3. Results and Discussion

Sound level readings taken during the two surveys are shown in Tables 2-4 and 2-5. The highest average decibel level was 83 dBA in the February survey and 79 dBA in the May survey. Both of these readings were obtained at the monitoring site near the headframe. Background noise levels were on the order of 25-30 dBA and were reached when readings were taken at distances greater than about one mile from mining activities. These same general decibel levels were found in readings taken on site boundaries. Exceptions to background noise were noted when there was aircraft passing overhead, vehicular traffic in the area or some other activity (e.g. drilling) near the monitoring site.

Noise levels taken during these two surveys were generally comparable to those taken during the August and October 1978 surveys, as reported in MDP Report 3. The only exception were the higher measurements taken near the headframe, reflecting greater onsite activity. Higher noise levels measured in January and March 1978, as reported in MDP Report 2, were probably due to differences in wind speeds and locations of the monitoring sites.

The potential for wildlife disturbances due to noise of this magnitude is anticipated to be small.

Table 2-4. Environmental Sound Level Measurements, RBOSC Tract C-a, February 19, 1979

Site	Time	Wind	Sound Level Measurements (dBA, Slow Response) (20 sec range) 1	2	3	4	5	Sound Level dBA Range	Sound Level dBA Average	Remarks
A	8:55	Calm	82-81	82-81	82-81	82-81	82-81	81-82	82	During hoist operation
1	9:02	Calm	36-35	38-36	38-36	37-35	37-35	35-38	36	Job noise only
2	10:15	Calm	64-43	41-38	38-35	41-36	59-40	35-64	44	Job noise, vehicle noise, airplane in distance
3	10:24	Calm	41-40	40-39	46-39	43-38	49-38	38-46	41	Truck unloading at warehouse, raven croaking, vehicle passing by
4	9:44	0-5/NE	44-41	42-40	42-41	44-42	46-43	40-46	43	Job noise, airplane
5	9:23	Calm	26-25	26-25	27-25	26-25	28-26	25-28	26	Job noise, vehicle noise
6	9:13	Calm	24-22	22-21	22-21	22-21	23-21	21-24	22	Job noise barely audible, raven croaking, airplane in distance
7	10:07	Calm	40-36	44-39	42-39	46-43	48-43	36-48	42	Job noise, semi-truck on site access road, airplane in distance
8	10:59	Calm	29-27	32-26	30-25	27-25	26-25	25-32	27	Vehicle near construction site
9	10:35	Calm	30-21	22-21	24-22	42-30	35-28	21-42	28	Airplane, dog chewing bone, human activity
10	10:45	5-10/W	48-29	47-35	48-32	43-28	51-28	28-48	39	Wind noise
11	9:55	Calm	40-34	42-33	30-29	39-31	40-32	29-42	35	Munson's well audible
12	9:32	Calm	24-22	23-22	22-22	22-21	23-22	21-24	22	Job noise barely audible, vehicle in distance
13	11:09	5/W	24-23	25-23	24-22	23-22	23-22	22-25	23	Some wind noise
14	11:19	5-10/W	39-20	44-32	42-20	39-26	42-30	20-44	33	Wind noise
15	11:28	8-12/W	39-24	33-22	40-21	40-22	39-22	21-40	30	Wind noise
A	12:02	5/W	84-82	84-83	84-83	84-83	84-82	82-84	83	During hoist operation

Table 2-5. Environmental Sound Level Measurements, RBOSC Tract C-a, May 22, 1979

Site	Time	Wind	Sound Level Measurements (dBA, Slow Response) (20 sec range) 1	2	3	4	5	Sound Level dBA Range	Sound Level dBA Average	Remarks
A	8:53	3-5/E	80-79	79-78	79-78	79-78	79-77	77-80	79	Job noise
1	9:00	0-5/E	50-41	44-40	42-40	45-42	49-44	40-50	44	Job noise, pickup truck highest readings
2	10:13	3-8/NE	39-33	49-37	49-40	49-37	43-44	34-49	41	Job noise, wind noise highest readings
3	10:22	3-5/NE	49-48	49-48	49-48	49-47	50-47	47-50	48	Job noise upwind and constant
4	9:40	3-8/N	37-32	44-37	40-37	48-37	42-36	32-48	39	Job noise
5	9:23	0-5/E	36-29	44-35	48-37	51-42	40-37	29-51	40	Jet airplane highest readings
6	9:13	0-5/E	36-26	36-23	27-24	25-23	29-24	23-36	27	Wind noise highest readings
7	9:59	3-10/E	50-35	34-30	34-29	39-29	39-31	29-50	35	Wind noise highest readings
8	10:52	5-8/N	38-33	31-26	49-45	45-38	46-36	26-49	39	Wind noise, jet airplane and pickup truck contributed to readings
9	10:31	3-8/E	31-23	27-24	33-24	28-23	39-24	23-39	28	Wind noise highest readings
10	10:40	3-8/E	39-23	40-25	40-23	26-23	36-22	22-40	30	Wind noise highest readings
11	9:47	2-5/NE	25-23	26-24	30-24	27-24	29-25	23-30	26	Highest readings from buzzing of syrphid fly
12	9:28	8-12/E	Wind noise too variable for reading: estimated 25-55 dBA for 8-20 second readings						-	
13	11:04	3-8/N	34-26	25-24	38-24	29-24	32-24	24-38	29	Wind noise highest readings
14	11:14	0-8/N	25-22	31-23	38-24	35-25	35-24	22-38	28	Wind noise and fly buzzing highest readings
15	11:25	3-8/SW	32-24	40-24	39-22	37-23	32-22	22-40	30	Wind noise and fly buzzing highest readings
16	10:05	3-8/NE	39-24	39-25	40-23	33-25	29-23	23-40	30	Wind noise highest readings
A	11:53	3-5/N	79-77	78-76	77-77	77-76	78-76	76-78	77	Job noise

2.5 SUMMARY AND CONCLUSIONS

Air quality and meteorological data were collected during the six-month reporting period. No unusual events or violations of National Ambient Air Quality Standards occurred. All of the air quality parameters were below the threshold of detection most of the time, with the exception of ozone and particulates. Ozone concentrations ranged from 0.029 to 0.071 ppm at Site 1, and from 0.008 to 0.070 ppm at Site 3. Particulate concentrations ranged from 1 to 34 ug/m^3 at the two sites measuring the ambient particulate level (Sites 1 and 2) and from 3 to 94 ug/m^3 at the site located in Corral Gulch (Site 3), which is often downwind of tract activities. These values are similar to those found in the 1977-78 mid-year report (MDP Monitoring Report 2).

The higher particulate concentrations at Site 3 are somewhat misleading in that the main tract access road (a dirt road) is also located within the gulch, approximately 100 yards from the hi-volume sampler. The data, designed to measure the effects of tract development, are therefore biased by the fugitive dust from the access road. Fortunately, the access road was paved early in the next reporting period (late June, 1979) so that it should be easier in the future to identify development-related effects on the ambient particulate concentrations.

No significant changes have been detected in the meteorological data collected during the six-month data period.

A Spring visibility study using both the traditional photometric method and a telephotometer to measure visual range has been initiated but was not completed during this reporting period. The results of the Spring visibility study will be reported, along with the results of the Fall visibility study, in the year-end report.

Two noise surveys were taken during the reporting period. During the February survey, sound level averages on the tract ranged from 22 to 44 dBA, except near the main construction area (adjacent to headframe)

which averaged 83 dBA. During the May survey, sound level averages ranged from 26 to 48 dBA, except an average of 78 dBA near the main construction area.

SECTION 3
TERRESTRIAL STUDIES

The Terrestrial Studies MDP Monitoring Program is designed to detect and evaluate those impacts affecting the vegetation or faunal components of the terrestrial ecosystems on or near RBOSC Tract C-a.

The Tract C-a terrestrial studies are geared to seasonal cycles of the ecosystem components. Therefore sampling is conducted during those seasons when activity is greatest (Table 3-1). The study period reported herein is December 1978 through May 1979. Several terrestrial programs had not been initiated or had been initiated but not completed at the end of the reporting period. Results of these programs, including Color infrared (CIR) photography, phytosociology, range productivity and utilization, avifauna, and small mammal studies will be reported in the MDP year-end report. Opportunistic observations of important events and unscheduled special studies will be reported in MDP monitoring reports as they occur.

The terrestrial monitoring program is based on an assessment of current knowledge of MDP mining operations. Because this is a prototype operation, new information may become available which requires a modification of the outlined program. Therefore, this monitoring program should be viewed as a flexible one which may change as engineering design is refined and as additional ecological data are obtained.

Table 3-1. Terrestrial Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
Vegetation Mapping	Tract C-a & 5-mile Perimeter	August 1978*	Every 3rd year
Vegetation Stress	Anticipated impact areas	June-July 1979	Annually
Vegetation Phytosociological Studies	See Map 2	May-June 1979	Once/3-yr period Rotation Basis
Range Productivity & Utilization	See Map 2	April 1978 (establish plots)	Annually (in Sept.)
Browse Condition & Utilization	See Map 2	May 1978	Annually
Small Mammals	See Map 2	May-June 1979	Annually
Avifauna Studies	See Map 2	May-June 1979	Annually
Mule Deer Density Studies	See Map 2	Sept. 1977	Annually
Mule Deer - Road Kill Studies	County Road 24	Feb. 1979	Weekly During Peak Migrations
Feral Horse Abundance	Tract C-a & 3-mile Perimeter	Jan. 1978	Annually

* 1978 aerial photography was accomplished in August; however, subsequent flights will be scheduled for June-July.

3.1 VEGETATION, RANGE, AND BROWSE

A. Vegetation

1. Objectives

Construction and operation at Tract C-a may affect the local distribution and condition of vegetation types. The vegetation study is designed to monitor the distribution of vegetation on Tract C-a and adjacent areas to determine large-scale changes resulting from MDP development, to identify stress conditions, and to document changes in the vegetative community over time. The vegetation study has two major components: color and CIR aerial photography and phytosociological studies.

2. Methods

Color aerial photography (1 inch = 2,000 feet scale) is taken at three-year intervals, with the photographed area including Tract C-a and the areas within a five-mile radius. These photographs are compared to the RBOSC vegetation map (RBOSP 1977) and earlier color aerial photographs to identify changes in the distribution of vegetation types. If changes are detected, the vegetation map will be modified to reflect them and an effort will be made to identify the source of the change. Color aerial photography is available for 1974 and 1978. The next flight will be flown in 1981 (Table 3-1).

CIR aerial photography (1 inch = 500 feet scale) is taken on an annual basis to assess vegetation stress conditions. If stress conditions are identified, additional sampling programs may be necessary to determine the extent and cause of the stress. CIR photography will include those portions of the region where appreciable concentrations of harmful air pollutants may occur as predicted by air plume models or detected by plume monitoring, where dewatering and/or reinjection has affected the alluvium or upper aquifers, or where surface water has been affected. Such areas will be determined in cooperation with the AOSO. Areas covered during the 1979 flight are indicated on Map 2 (see map pocket).

3. Results and Discussion

CIR aerial photography at the aforementioned scale was conducted in June 1979; consequently, no results are available as yet.

B. Range

1. Objectives

MDP activities on Tract C-a may affect range conditions on and near the tract by altering use patterns of deer, cattle, and feral horse populations resulting in increased grazing pressure on some portions of Tract C-a. The range studies are designed to provide information on vegetative production which can be used to compare range productivity before and during modular development. Because activities are confined primarily to the mine process area, impacts on range conditions are projected to be localized. Therefore, range studies focus on areas of Tract C-a that are adjacent to MDP activities and that were previously used for grazing.

2. Methods

The methods followed for collection of range data were described in RBOSC MDP Monitoring Reports 1, 2, and 3 and are not repeated herein.

As specified by sampling procedures, range cage positions were established during early May 1979. Cages were placed five meters to the left of the transect sample stakes (sighted from station 1 to station 10). At site PJ 16 (see Map 2 in map pocket) the transect is composed of two segments due to the limited extent of the pinyon-juniper stand at that location. Because of the close proximity of these two segments, range cages could not be placed five meters to the left of sampling stakes. In this instance cages were placed 2.5 meters to the outside of each transect segment.

3. Results and Discussion

Sampling will be conducted in September and results reported in the year-end report.

C. Browse

1. Objectives

Tract C-a development may reduce browse availability and therefore affect animal distribution in the vicinity of Tract C-a. The browse condition and utilization studies are designed to provide browse use information for areas adjacent to Tract C-a development.

2. Methods

The methods followed for collection of browse data were described in RBOSC MDP Monitoring Reports 1 and 2. Locations of sample transects are the same as those for range productivity studies and are illustrated on Map 2 (see map pocket).

On four transects (sample units MB 31 and 33, PJ 5, and SB 39) some of the markers identifying shrubs were missing. The number of individual shrubs not marked included 25 individuals on each of the mixed brush transects, 9 individuals on PJ 5, and 18 shrubs on transect SB 39. Shrubs lacking markers were retagged in Spring 1979, but some shrubs on these transects may not be the same ones used in previous years. This accounts for variations in the number of plants of each species which were sampled during 1979.

3. Results and Discussion

The data obtained during May 1979 (Appendix 3-1.1) are summarized in Table 3-2.

a. Mixed Brush - Of the five shrub species sampled in the mixed brush habitat type, mountain mahogany had the greatest utilization (35.4%) whereas snowberry had the lowest utilization (4.5%) (Table 3-2). Mountain mahogany exhibited a three-fold increase during the 1979 browse season over the 1978 season. In spite of this increase, mountain mahogany browse leader use would be termed "acceptable" by Cole (1963) for "average" winter conditions.

The browse condition rating for mountain mahogany was "poor" whereas the remaining species continued to be categorized as being in "good" condition (Cole 1963). These ratings are the same as those observed for the mixed brush habitat type during the 1978 season.

When all species are considered, the weighted average percent utilization for the mixed brush type was slightly greater in 1979 than that for 1978 (Table 3-3). However, utilization for the mixed brush type has exhibited noticeable fluctuations among years.

Table 3-3. Comparison of Average Utilization (in percent) in Three Vegetation Types During April 1976, May 1977, May 1978, and May 1979 on and Near Tract C-a.

Vegetation Type	April 1976	May 1977	May 1978	May 1979
Mixed Brush	12	17	7	8
Pinyon-Juniper	27	24	31	15
Upland Sagebrush		6	25	4

b. Pinyon-Juniper - Utilization of shrubs in the pinyon-juniper type ranged from 0.1 to 66.7 percent (Table 3-2). Mountain mahogany, snowberry, and serviceberry exhibited the highest utilization (55.9, 66.7, and 29.0% respectively). Sagebrush, the most abundant species, averaged 11.7 percent utilization as compared to 23.8 percent in 1978. High utilization of mountain mahogany and snowberry indicates that use

Table 3-2. Condition of Important Browse Species Sampled in Three Vegetation Types During May 1979 in the Vicinity of RBOSC Oil Shale Tract C-a.

Habitat Type	Species	Number Plants Sampled	Average Util. (%)	Average Avail. (%)	Form Class (%)								Age Class (%)				Hedging Class (%)		
					1	2	3	4	5	6	7	8	Seedling	Young	Mature	Decadent	Light	Moderate	Severe
MB	Serviceberry	128	9.0	78.4	38	12	6	13	16	7	-	8	2	6	53	38	53	30	17
	Sagebrush	61	5.0	81.1	31	23	-	10	16	10	-	10	-	-	66	34	45	45	9
	Snowberry	41	4.5	62.9	34	2	-	27	22	5	5	5	2	10	34	54	64	31	5
	Mountain Mahogany	14	35.4	83.8	7	36	14	7	7	14	-	14	14	-	57	29	17	50	33
	Pinyon Pine	6	7.8	100.0	50	33	-	17	-	-	-	-	-	-	100	-	67	33	-
PJ	Sagebrush	103	11.7	68.9	15	12	7	15	17	22	-	13	1	-	41	58	32	33	34
	Pinyon Pine	50	6.5	65.2	28	8	10	20	12	-	20	2	6	6	80	8	61	29	10
	Juniper	37	0.1	42.8	24	-	-	24	16	3	19	14	-	3	73	24	75	22	3
	Bitterbrush	36	23.1	64.6	3	17	8	3	36	25	-	8	-	-	39	61	6	58	36
	Mountain Mahogany	17	55.9	69.5	-	-	12	-	6	82	-	-	-	-	65	35	-	-	100
	Snowberry	4	66.7	34.0	-	25	50	-	-	-	-	25	-	-	75	25	-	33	67
	Serviceberry	3	29.0	23.3	-	33	-	33	-	33	-	-	-	-	33	67	33	33	33
SB	Sagebrush	235	3.9	78.6	17	14	3	12	14	16	-	23	-	-	49	51	37	37	26
	Serviceberry	11	3.3	85.6	45	18	-	18	-	-	-	18	-	18	55	27	89	11	-
	Snowberry	4	0.0	28.8	-	-	25	-	75	-	-	-	-	-	25	75	-	75	25

MB = Mixed Brush
PJ = Pinyon-Juniper
SB = Sagebrush

Form Classes

1 All available, little or no hedging
2 All available, moderately hedged
3 All available, severely hedged
4 Partially available, little or no hedging
5 Partially available, moderately hedged
6 Partially available, severely hedged
7 Unavailable
8 Dead

of these species exceeds that which is deemed "acceptable" for average winter browse conditions. However, use of the mountain mahogany, a preferred browse species, decreased relative to 1978 use. This decrease might be expected due to harsh winter conditions which caused deer to migrate off tract to elevations lower than those utilized during the 1978 browse season.

The browse condition ratings for mountain mahogany and snowberry were "very poor" for the 1979 sample period. Sagebrush, bitterbrush, and serviceberry had "poor" browse condition ratings, whereas pinyon and juniper had respective classifications of "good" and "excellent". These ratings are similar to those exhibited in 1978.

Average weighted percent utilization for all species in the pinyon-juniper type in 1979 was 15 percent (Table 3-2). This represents a 50 percent reduction from 1978 data and is consistent with the assumption that the harsh winter resulted in reduced browse use in the vicinity of Tract C-a.

c. Upland Sagebrush - Sagebrush had an average utilization of 3.9 percent in 1979 and serviceberry exhibited a slightly lower use of 3.3 percent (Table 3-2). These data represent an important decrease from 1978 usage, when respective percentages were 26.3 and 13.5 percent. The 1979 leader use indicates that both sagebrush and serviceberry are well below the allowable use levels for a mild browse winter. As with the other habitat types, reductions in use can be attributed to abnormal winter conditions which resulted in fewer individuals utilizing the area around Tract C-a.

Browse condition ratings for both sagebrush and serviceberry are "fair", as based on the percentage of severely hedged plants. This represents no change from the 1978 data.

Overall utilization for the sagebrush habitat type was 4 percent as compared to 25 percent for 1978 (Table 3-3). Levels of use for 1979 are also lower than those recorded for 1977.

3.2 FAUNA

A. Mule Deer

1. Pellet Groups Count

a. Objectives - Mule deer are the most important game species in Colorado in terms of recreational use and money expended by hunters. The Piceance Creek Basin mule deer herd is one of the largest migratory mule deer herds in North America. Tract C-a is within the Piceance Creek Basin and Colorado Division of Wildlife's (CDOW) Game Management Unit 22.

Moderate numbers of mule deer occur on Tract C-a during fall and spring migration periods and during mild winters; at other times mule deer are relatively uncommon on the tract. Consideration of the possible effects of Tract C-a oil shale development on mule deer is an integral part of RBOSC's Fish and Wildlife Management Plan.

The objectives of RBOSC's mule deer monitoring program are to obtain an index of mule deer density in a 9 x 9 mile (81 sq mile) study area centered on Tract C-a (see Map 2 in map pocket), to compare indices of mule deer density from the study area with those from the Game Management Unit 22, and, if possible, to compare differences in mule deer densities within various portions of the study area.

b. Methods - Mule deer density estimates can be calculated from pellet-group density data since mule deer defecate a more or less uniform number of times daily (Neff 1968). The number of pellet-groups per unit area, days of use by deer, and deer per unit area in the Tract C-a study area are being determined as described by Overton (1971). The methods followed for collection of these data were described in RBOSC MDP Monitoring Report 1 and are not repeated herein.

c. Results and Discussion - Mule deer pellet groups were counted in 63 quarter section sample units in the nine square mile blocks comprising the Tract C-a study area (Map 2 in map pocket) in Spring 1979. Summary pellet group information from this sample period is presented in Table 3-4. Analyses of deer use days and indices of deer densities for sample units, blocks, and the entire study area will be reported in the 1979 year-end report. Comparisons of deer population parameters on the Tract C-a study area with similar available parameters about deer populations in the Piceance Creek Basin will also be included in that report.

Based on the data presented in Table 3-4, it appears that the tract (Block 5) and Block 2, north of the tract, sustained more deer use during the winter of 1978-79 than did other portions of the study area. Also, the study area received lower deer use during this winter than during the winter of 1977-78. However, the distribution of deer throughout the study area was non-uniform as expected. Many environmental factors govern the population density and distribution of deer on a given range for a given season. Changes in distribution and trends in deer population, as expressed by densities of pellet groups, cannot be determined until the fall data have been collected and analyzed for comparisons with previously collected data. Results of these analyses and comparisons with the results of the previous year will be presented annually in the year-end report.

2. Mule Deer Road Kill Study

The Piceance Creek Basin is the current center of a great deal of energy development activity including oil shale and natural gas. This increased activity has resulted in increased traffic flows across mule deer migration routes. The CDOW is interested in obtaining data relative to the mortality of mule deer as a result of deer-vehicle collisions.

a. Objectives - The objective of this program is to provide data on mule deer mortality along County Road 24 from Piceance Creek to Tract C-a for compilation and use by the CDOW.

Table 3.4 Mule Deer Pellet Groups Counted on RBOSC Tract C-a Study Area, Spring 1979

Block and Sample Unit	Number of Pellet Groups in Sample Unit	Total Number of Pellet Groups in Block	Average Number of Groups Per Sample Unit For Each Block	Average Number of Deer Per Square Mile For Each Block[1]
1-5	7			
1-11	14			
1-16	5			
1-20	7			
1-23	16			
1-26	10			
1-31	10	69	9.86	54.6
2-5	10			
2-6	9			
2-15	33			
2-17	9			
2-24	7			
2-28	3			
2-34	9	80	11.43	63.3
3-1	4			
3-11	6			
3-14	5			
3-17	5			
3-18	2			
3-19	5			
3-34	10	37	5.29	29.3
4-1	9			
4-8	1			
4-13	1			
4-14	2			
4-18	8			
4-23	9			
4-25	1	31	4.43	24.5
5-8	18			
5-13	16			
5-15	21			
5-27	8			
5-28	7			
5-29	5			
5-36	5	80	11.43	63.3

Table 3.4 (Continued)

Block and Sample Unit	Number of Pellet Groups in Sample Unit	Total Number of Pellet Groups in Block	Average Number of Groups Per Sample Unit For Each Block	Average Number of Deer Per Square Mile For Each Block[1]
6-8	27			
6-11	10			
6-14	11			
6-27	6			
6-30	3			
6-32	0			
6-35	4	61	8.71	48.3
7-16	4			
7-17	3			
7-19	3			
7-22	4			
7-28	4			
7-32	5			
7-34	4	27	3.86	21.4
8-3	9			
8-5	2			
8-11	0			
8-13	10			
8-14	4			
8-27	2			
8-34	1	28	4.00	22.2
9-3	4			
9-7	3			
9-9	5			
9-15	0			
9-21	4			
9-30	3			
9-35	1	20	2.86	15.8

[1]Assuming 180 days in the winter sampling period, presence of deer throughout the period, and 13 pellet groups per deer per day. More detailed analyses per plot are being conducted and will be reported in the year-end report.

b. Methods - Mule deer mortality data are collected three times per week, along a 13-mile stretch of County Road 24 from Piceance Creek to Tract C-a during prime migration periods (September - March). Data are recorded on a field log by the RBOSC Wildlife Biologist each sample day.

At the initial observance of a new carcass, the location is marked on a map using a number representing the sequential kill count of the week. Duplication of counts is avoided by conspicuously marking the carcass with flagging. Marked carcasses are omitted from subsequent counts. A new map is used each week, and weekly kill counts, as marked on the map, plus supplementary data are forwarded to the CDOW (through the Area Oil Shale Supervisor) on a monthly basis. Maps are sequentially numbered and dated for identification. This information is duplicated in the weekly field log.

c. Results and Discussion - Locations of deer kills by collisions with vehicles along County Road 24 during the study period are shown on Figure 3-1. Deer were very numerous along this road in late winter and early spring, 1979. One evening in March, approximately 1,300 deer were counted adjacent to the length of County Road 24. Despite the heavy traffic and abundance of deer, only nine deer killed by collisions with vehicles were found during the reporting period. Deer road kills during the 1979 fall migration period will be reported and compared with the road kills during the 1979 spring migration period in the year-end report.

B. Feral Horses

1. Objectives

Feral horses occur on and in the vicinity of Tract C-a. These horses are protected under federal law and are under the jurisdiction of the BLM. Feral horses compete with cattle and, to a lesser extent, with mule deer for available forage. The objective of feral horse monitoring

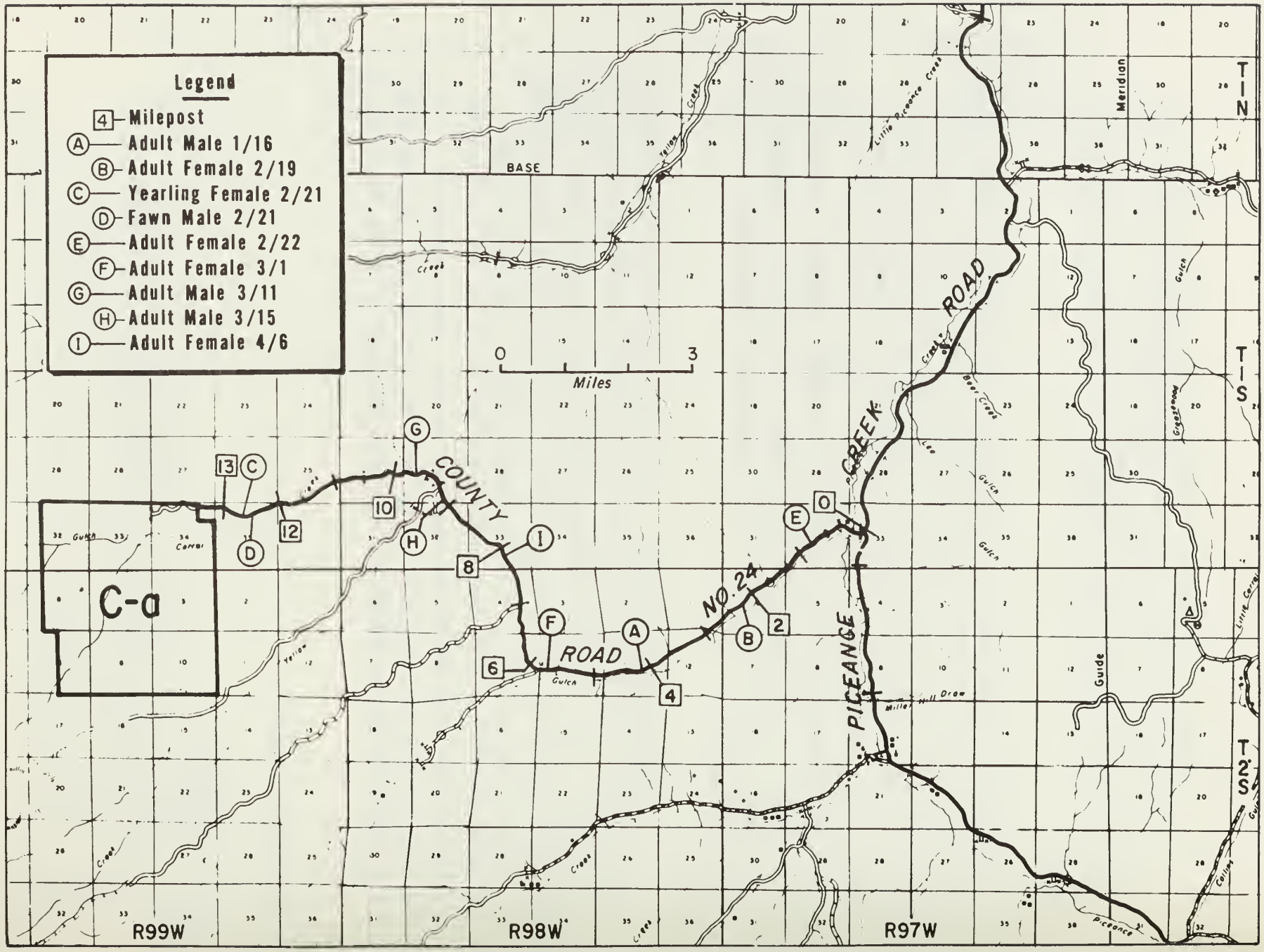


Figure 3-1 Deer killed along Rio Blanco County Road 24; December 1978 - May 1979.

studies is to provide qualitative information concerning the status of feral horses in the RBOSC study area (i.e., same study area as for mule deer).

2. Methods

The methods followed for collection of data on feral horses were described in RBOSC MDP Monitoirng Report 1 and are not repeated herein.

3. Results and Discussion

Feral horses on the Tract C-a study area were counted from a helicopter in January 1979. Twenty-one bands of horses totaling 99 individuals were observed in the study area (Figure 3-2). Weather conditions during the count were ideal for horse observation: a warm, sunny day following several days of snowfall. The January count probably included almost all of the horses in the area since most horses were seen basking in the sun. Further feral horse observations and estimated foal success will be reported in the 1979 year-end report.

C. Threatened, Endangered and Protected Species

Baseline and interim monitoring studies indicate that Tract C-a does not provide critical habitat for any state or federally endangered species. Greater sandhill cranes were observed during the baseline studies on 84 Mesa, at the Stake Springs impoundment, and east of 84 Ranch. A whooping crane was sighted east of 84 Ranch. Neither of these species was observed during the reporting period nor in recent studies.

A pair of golden eagles, protected in Colorado, nested at milepost 5 along County Road 24 during the reporting period. One eaglet fledged from that nest on July 4, 1979, in spite of heavy road traffic and the paving of that road during June.

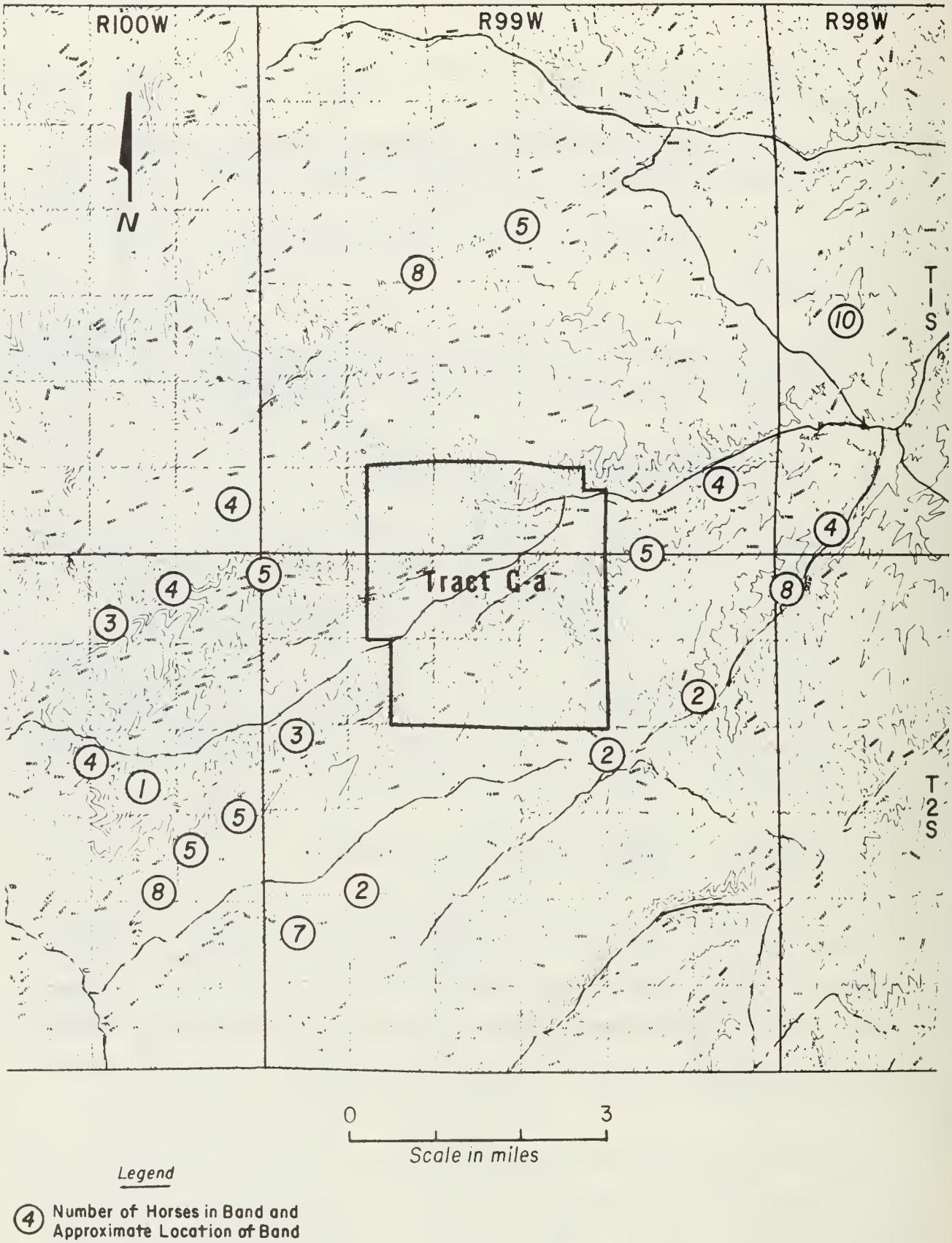


Figure 3-2 Feral Horses Observed During the January 1979 Aerial Census.

3.3 SUMMARY AND CONCLUSIONS

The components of the Terrestrial Monitoring Program examined during the reporting period were browse condition and utilization, mule deer density, mule deer road kills and feral horse abundance. Results from these studies are similar to those of previous sampling periods.

Browse utilization studies indicate the average percent utilization of browse species ranged from 4 percent in the upland sagebrush to 15 percent in the pinyon-juniper vegetation type. Utilization in both of these vegetation types decreased from that experienced in 1978 whereas use in the mixed brush type increased slightly. Lower use in the sagebrush and pinyon-juniper vegetation types is consistent with the evidence that the harsh winter caused deer to migrate off tract and use habitats at lower elevation.

Browse condition ratings for the three vegetation types were similar to those present during the 1978 sampling period. Most species exhibited "fair" or "good" browse condition. However, mountain mahogany had "poor" browse condition rating in the mixed brush and a "very poor" rating in the pinyon-juniper vegetation type. Snowberry also exhibited "very poor" browse condition in the pinyon-juniper type, whereas sagebrush, bitterbrush, and serviceberry had "poor" browse condition.

Based upon the number of pellet groups counted, mule deer use of the Tract C-a area was somewhat lower this winter than the winter of 1977-1978. An average use of 38.1 deer per square mile was found for 1978-79 as compared to an average of 44.7 deer per square mile for 1977-78. This reduced use probably can be attributed to increased snowfall which pushed the deer to lower elevations off the study area.

Nine deer killed by collisions with vehicles were found along County Road 24 during the reporting period. Deer were very abundant along this road during the study period, and the number of road kills is low considering the heavy traffic and poor road conditions during that time.

A total of 99 feral horses in 21 bands was counted in the study area during the winter aerial horse count. This density of horses is comparable to that estimated in the study area for the previous winter.

LITERATURE CITED

Cole, G. F. 1963. Range survey guide. U.S.D.I., Grand Teton National History Association, Grand Teton National Park, Moose, Wyoming

Neff, D. J. 1968. The pellet group count technique for big game trend, census, and distribution: a review. J. Wildl. Manage. 32 (3): 597-614.

Overton, W.S. 1971. Estimating the numbers of animals in wildlife populations, pp. 403-456 in Giles, R. H. Jr. (ed.), Wildlife Management Technique. Edwards Bros. Inc., Ann Arbor, Michigan.

SECTION 4
AQUATIC STUDIES

The MDP Aquatic Monitoring Program is designed to provide information on aquatic ecosystems in the vicinity of Tract C-a appropriate to identifying and measuring the potential effects of modular development on local aquatic biota. The program design was based on a complete evaluation of data obtained during the RBOSC baseline program and upon projected impacts of project activities. Criteria for selecting aquatic parameters to be measured included ecological importance, sensitivity to environmental change, and ease of sampling. A detailed list of parameters measured at each sampling location and sampling frequency are provided in Table 4-1.

Six sampling sites are used in the MDP monitoring program (see Map 2, Map Pocket):

- Station 13 (spring-brook habitat) at the USGS gaging station in Corral Gulch (east)
- Station 14 (pond habitat) in Corral Gulch (east)
- Station 20 (spring-brook habitat) at the USGS gaging station on Yellow Creek
- Station 21 (spring-brook habitat) on Yellow Creek below the USGS gaging station
- Station 27 and 29 (White River back channel habitats) near the confluence of Yellow Creek with the White River.

Sampling was initiated in October, 1977. This report provides results from April 1979 sampling. Brief comparison with April samples from previous years and identification of significant trends or findings are presented. A detailed evaluation of 1979 aquatic monitoring data will be included in the year-end report.

Table 4-1. Aquatic Studies Monitoring Schedule

Parameter	Location	Frequency
Abiotic Component		
Physical Measurements		
Stream Velocity		
Turbidity		
Dissolved Oxygen	Stations 13, 14, 20, 21, 27, 29 (See Map 2, Map Pocket)	6 times/year (Apr. May, June, July, Aug., Oct.)
pH		
Specific Conductance		
Depth		
Width		
Stream Substrate		
Water Quality Measurements (White River)		
Boron		
Calcium		
Chloride		
Fluoride		
Magnesium	Stations 27, 29 (See Map 2, Map Pocket)	6 times/year (Apr., May, June, July, Aug., Oct.)
Nitrate		
Orthophosphate		
Potassium		
Total Phosphate		
Silica		
Sulfate		
Sodium		
Alkalinity		
Total Dissolved Solids		
Bicarbonate		

Table 4-1. (Continued)

Parameter	Location	Frequency
Biotic Component		
Periphyton		
species composition relative abundance biomass diversity	Stations 13, 14, 20, 21, 27, 29 (See Map 2, Map Pocket)	6 times/year (Apr.,May, June, July, Aug., Oct.)
Benthos		
species composition relative abundance diversity	Stations 13, 14, 20. 21, 27, 29 (See Map 2, Map Pocket)	6 times/year (Apr.,May, June, July, Aug., Oct.)

4.1 ABIOTIC COMPONENTS

A. Physical Measurements

1. Objectives

The physical measurement program is designed to monitor selected physical parameters at MDP aquatic sampling stations and relate these data to water quality and aquatic biota conditions. The physical parameters selected for monitoring are those which may be indicative of effects related to project activities (e.g., increased siltation and turbidity and decreased flows) and which have shown to be of particular significance to the important aquatic organisms observed during baseline studies. Chemical parameters, such as dissolved oxygen, which are recorded in conjunction with the physical measurement program, are presented and discussed in this section as well.

2. Methods

Methods used to collect physical stream data were described in RBOSC MDP Monitoring Report 1 and are not repeated herein.

3. Results and Discussion

A comparison of physical measurement data collected in April 1979 with results obtained during April sampling in previous years is provided in Table 4-2. April 1979 data collected at each sampling station are presented in Appendix 4-1.1.

The data in Table 4-2 indicate a good deal of year-to-year vaiability in physical parameters. However, no significant trend or permanent change is noted in any given parameter. The observed variability could result from a number of factors including amount of runoff from recent precipitation, ground water injection tests or melting of winter snowpack and weather conditions just prior to and during sampling.

Table 4-2. Comparison of Physical and Chemical Characteristics of Streams From RBOSC MDP Studies (April, 1978 and 1979) and RBOSC Baseline Studies (April, 1975 and 1976).

Parameter	1975	1976	1978	1979
		Station 13		
Water Temperature (^{o}C)	9	13	17	15
Conductivity (µmhos/cm)	1,730	1,150	1,500	1,050
Dissolved oxygen (mg/l)	5.2	7.8	5.1	6.3
Alkalinity, total (mg/l)	716	435	584	450
pH	8.3	7.5	8.3	7.8
Substrate[1]	Gr,Si	Gr,Sa	Gr	Gr
Width	3'	4'	3'6"	4'9"
Depth	3"	4"	6"	9"
Velocity (ft/sec)	1.0	1.4	2.0	2.5
		Station 14		
Water Temperature (^{o}C)	5	9	16	17
Conductivity (µmhos/cm)	1,800	1,750	1,400	2,000
Dissolved oxygen (mg/l)	11.1	9.7	10.1	8.5
Alkalinity, total (mg/l)	492	546	424	600
pH	8.4	7.9	8.4	7.0
Substrate[1]	Si	Sa	Sa,Si,De[2]	Sa,Si
Width	3"	18"	6"	102"
Depth	2"	4"	6"	8"
Velocity (ft/sec)	0.5	1.2	1.0	1.0

Table 4-2. (Continued)

Parameter	1975	1976	1978	1979
		Station 20		
Water Temperature (^{o}C)	14	19	16	22
Conductivity (μmhos/cm)	3,700	4,000	4,200	2,500
Dissolved oxygen (mg/l)	9.4	9.4	8.2	8.7
Alkalinity, total (mg/l)	1,291	1,632	1,444	1,544
pH	8.6	8.7	8.1	8.3
Substrate[1]	Gr,Si,Sa	Gr	Co,Gr	Gr,Sa
Width	12'	5'	3'	6'8"
Depth	4",3"	4"	4"	5"
Velocity (ft/sec)	1.6,1.0	1.1	1.5	1.3
		Station 21		
Water Temperature (^{o}C)	14	18	13	21
Conductivity (μmhos/cm)	3,700	3,900	4,200	3,220
Dissolved oxygen (mg/l)	8.9	10.2	6.9	8.6
Alkalinity, total (mg/l)	1,306	1,658	1,532	1,554
pH	8.6	8.7	8.7	8.4
Substrate[1]	Gr,Si	Gr	Gr,Sa	Gr,Sa
Width	5'5"	6'	4'	9'3"
Depth	5",3"	4"	4"	3"
Velocity (ft/sec)	1.3,1.7	0.9	1.0	1.7

Table 4-2. (Continued)

Parameter	1975	1976	1978	1979
		Station 27		
Water Temperature (^{o}C)	15	17	9	11.3
Conductivity (µmhos/cm)	850	650;640;650[2]	700;700;700[2]	600;600;600[2]
Dissolved oxygen (mg/l)	9.8	10.6	9.6	9.3
Alkalinity, total (mg/l)	207	188	184	182
pH	8.5	8.4	8.2	7.5
Substrate[1]	Gr,SC^{o}	Co	Co,Si	Co,Gr
Width	46'6"	51'	51'	54'4"
Depth	2";23";4"[2]	4";22";8"[2]	8";10";4"[2]	14";15"8"[2]
Velocity (ft/sec)	3.0;2.8;2.5[2]	1.2;1.0;0.7[2]	1.2;1.9;1.4[2]	1.9;2.0;1.2[2]
		Station 29		
Water Temperature (^{o}C)	13	11	9	11.5
Conductivity (µmhos/cm)	850	730;800;1,150[2]	750;800;900[2]	600;600;1,000[2]
Dissolved oxygen (mg/l)	10.1	10.5	9.3	9.5
Alkalinity, total (mg/l)	207	186	214	179
pH	8.4	8.4	8.2	7.5
Substrate[1]	Gr,SC	Gr,Sa	Co,Si	Gr
Width	20'10"	25'	36'	47'6"
Depth	1";11";1"[2]	4":12";2"[2]	8";10";14"[2]	10";11";14"[2]
Velocity	1.9;3.6	2.8;3.9;1.9[2]	2.4;2.7;2.3[2]	2.3;3.6;2.1[2]

[1] Substrate abbreviations:

Gr = Gravel
Sa = Sand
De = Detritus
Co = Cobble
Cl = Clay
Si = Silt

[2] Measurements made at side, center, side, respectively because of width and rate of flow of the White River at these locations.

A larger volume of water appeared to be flowing at all stations during April, 1979, as indicated by increased stream width and depth measurement. However, there was no appreciable change in stream velocity. The only other discernible change in physical parameters in April 1979 from previous year's samples was an increase in conductivity and alkalinity and a decrease in dissolved oxygen and pH at Station 14 (Corral Gulch).

B. Water Quality Measurements

1. Objectives

Water quality has important ramifications to both the many potential uses of the White River and the distribution and abundance of White River biota. Measurement of certain key chemical parameters at stations along the White River above and below the influx of water from the project site will provide a good index to water quality. These parameters were selected on the basis of results obtained during baseline studies and represent the best indicators of natural variability in White River water quality. Water quality data in other surface waters of the site are collected during hydrology studies (Section 5).

2. Methods

Methods used to collect and analyze water quality samples were described in RBOSC MDP Monitoring Report 1 and are not repeated herein.

3. Results and Discussions

A comparison of the results of the April 1979 water quality analyses of White River waters above and below the confluence with Yellow Creek with those obtained during previous years are provided in Tables 4-3 and 4-4. Results of the April 1979 water quality analysis of White River waters above and below the confluence with Yellow Creek are presented in Appendix 4-1.2.

The data in Tables 4-3 and 4-4 indicate little change in White River water quality from baseline condition and no significant difference between the

Table 4-3. Comparison of Water Quality Data from the White River (Upstream of Yellow Creek) from RBOSC Aquatic Baseline (April, 1975) and MDP (April, 1978 and 1979) Studies. (Results are expressed as the means of two replicates and are mg/l unless otherwise noted).

Parameter	1975	1978	1979
Boron (B), diss	0.5	<0.5	<0.5
Calcium (Ca), diss	66	71	59
Chloride (Cl), diss	28	29	22
Fluoride (F), diss	0.60	0.27	0.15
Magnesium (Mg), diss	24	24	20
Nitrate (n), diss	<0.2	<0.2	<0.2
Phosphorus, Ortho (P), diss	<0.01	0.01	0.01
Phosphorus, total (P), diss	0.28	0.02	0.02
Potassium (K), diss	2.7	2.1	2.0
Silica (Si), diss	6.1	6.3	6.3
Sodium (Na), diss	59	47	39
Solids, diss	476	444	378
Sulfate (S)	55	49	40
Turbidity (JTU)	93	4	98

diss = dissolved

Table 4-4. Comparison of Water Quality Data from the White River (Downstream of Yellow Creek) from RBOSC Aquatic Baseline (April, 1975) and MDP (April, 1978 and 1979) Studies. (Results are expressed as the means of two replicates and are mg/l unless otherwise noted).

Parameter	1975	1978	1979
Boron (B), diss	<0.5	<0.5	<0.5
Calcium (Ca), diss	62	71	60
Chloride (Cl), diss	28	32	31
Fluoride (F), diss	0.70	0.28	0.17
Magnesium (Mg), diss	22	27	20
Nitrate (n), diss	<0.2	<0.2	<0.2
Phosphorus, Ortho (P), diss	<0.01	0.01	<0.01
Phosphorus, total (P), diss	0.18	0.02	0.02
Potassium (K), diss	2.6	2.3	2.0
Silica (Si), diss	6.2	6.3	6.0
Sodium (Na), diss	58	64	44
Solids, diss	467	483	396
Sulfate (S)	53	51	41
Turbidity (JTU)	69	3	103

diss = dissolved

water quality above and that below Yellow Creek since the initiation of project activities. There is a large fluctuation in turbidity in the three year's samples. However, this fluctuation may be related to the coincidence of sampling with spring run-off in 1975 and 1979, whereas, the 1978 sampling occurred before the run-off began.

4.2 BIOTIC COMPONENTS

A. Periphyton

1. Objectives

Sensitivity of periphyton to changes in their environment has been well documented. Species composition and relative abundance of the total periphyton community and key periphyton species can provide good indicators of potential project effects on Tract C-a vicinity aquatic systems. Periphyton communities are amenable to sampling techniques that provide a good quantitative data base for identifying changes quickly and accurately. Consequently, the study of periphyton communities is an important part of the MDP Monitoring Program. Species composition, relative abundance, biomass and diversity are the periphyton parameters being measured.

2. Methods

Periphyton is collected from natural substrates at each of the six locations during each sampling period. Six replicate samples are taken from Stations 13 and 14 (Corral Gulch), 27 and 29 (White River), while 10 replicates are collected from Stations 20 and 21 (Yellow Creek). For each sample replicate, an immersed rock is collected from areas of equivalent flow, if possible. Rocks that have a relatively flat upper surface and are positioned at mid-depth in riffles are generally selected for the collection of samples. The rocks are carefully removed from the streams and each replicate is taken by removing the periphyton from a 50 cm^2 area on the upper surface with scraping, brushing, and rinsing. The resulting algal solution is placed into a labelled glass sample container. Two replicates from each station are dried for

biomass analysis. The remaining samples are immediately preserved with neutralized formalin solution for taxonomic identification and enumeration.

a. Identification and enumeration - To prepare the samples for laboratory analysis, a permanent voucher slide is prepared for each replicate sample according to the procedure described below.

Samples are permitted to remain undisturbed at room temperature for a minimum of three days. Following this sedimentation period, water is added or supernatant removed to attain a standard total volume of 100 ml. After shaking samples vigorously to distribute the periphyton organisms uniformly, a 10 ml aliquot is withdrawn from each sample and introduced into a small labelled subsample vial. Acid fuchsin vital stain is added to each subsample vial and permitted to stand for 20 minutes in order to color the chlorophyll-containing cells. The stained subsamples are transferred to centrifuge tubes and centrifuged at 2,480 rpm after which the supernatant is removed with a syringe. The concentrated algae are resuspended in denatured ethanol, centrifuged, and the supernatant removed. This alcohol wash procedure is repeated a second time yielding a 1 ml volume of stained periphyton-alcohol concentrate. Two to 20 drops of the periphyton concentrate is delivered from calibrated pipettes onto labelled glass slides and mixed with Hyrax (supplied by Custom Research and Development, Inc.), a high resolution mounting medium (Nd = 1.63 to 1.51). The Hyrax-periphyton mixtures are heated gently and covered with clean ultrathin coverglasses.

The periphyton samples are examined utilizing a research grade compound microscope at magnifications of 100 X, 400 X, and 1,000 X. Wet mounts of the unstained material are examined to identify non-diatom periphyton which often are damaged in the staining procedure. Counts are made from the prepared slides of the stained periphyton organisms only. The counting method described by Margalef (1974) and outlined in Vollenweider (1974) is utilized so as not to bias any sample because of a dense or sparce periphyton slide preparation. Counts are made along randomly located transects counting until at least 100 units of the most dominant diatom have been encountered. A minimum transect area of 0.127 mm^2 is examined in all cases. All counts are made

at a magnification of 1,000 X. Transect width is a microscope field (0.18 mm) and lengths are variable. Each cell is counted as a unit, except for filamentous algae, where each 50 u segment is counted as one algal unit.

Each prepared slide is scanned at 100 X after counting to identify larger rare specimens present in the sample but not encountered while counting.

All identifications, counts, and other pertinent data are recorded on standard algal bench forms. Standard phycological references are used in the identification of the periphyton.

Periphyton densities are calculated according to the following equation:

$$\text{Units/mm}^2 = \frac{Ct \times Ac \times D \times Vo \times Vc}{At \times Nt \times Nd \times Vs \times Ao}$$

where: Ct = count per species
Ac = area of coverslip (mm^2)
D = number of drops per ml for pipette
Vo = initial sample volume (ml)
Vc = concentrate volume (ml)
At = area of counting transect (mm^2)
Nt = number of transects counted
Nd = number of drops per slide
Vs = subsample volume (ml)
Ao = original area scraped (mm^2)

b. Biomass determinations - The periphyton biomass samples are dehydrated in the sample collection bottles in a drying oven at 105-110 C. Periphyton from the sample bottles are then scraped and rinsed into labelled porcelain drying dishes. Each sample is dried to a constant weight in a drying oven at 105-110 C. Samples are cooled to room temperature in a dessicator and weighed to the nearest 0.0001 g (gross dry weight). After ashing at 500-550 C for about four hours in a muffle furnace, the samples are rewet upon cooling to replace their water of hydration, redried to a constant weight at 105-110 C and weighed to the nearest 0.0001 g (gross ash weight). Ash-free dry weight is

determined by subtracting gross ash weight from gross dry weight since the evaporating dish tare is assumed to be identical for the two weights.

Ash-free dry weight biomass is calculated according to the following equation:

$$\text{biomass } (mg/cm^2) = \frac{Wd - Wa}{As}$$

where: Wd = dry weight + tare (mg)
Wa = ash weight + tare (mg)
As = area scraped from rock substrate (cm^2)

3. Results and Discussion

In April 1979 a total of 99 taxa was identified from the periphyton samples (Appendix 4-2.1). Periphyton identification and enumeration and biomass data are provided in Appendix 4-2.1a. A listing of taxa encountered at each sampling site is presented in Appendix 4-2.1b. Density and biomass calculations are given in Appendices 4-2.1c and 4-2.1d, respectively. A summary and comparison of mean densities of the abundant taxa (representing greater than one percent of the total density) of April 1979 data with the results of previous April samples (1975-1978) are presented in Table 4.5. A comparison of mean biomass weights over the 1975-1979 study period are presented in Table 4.6.

Total mean periphyton density values varied from 10,163 units/mm^2 at Station 14 in Corral Gulch to 193 units/mm^2 at Station 29 in White River in April 1979. These values were generally lower than those of April samples in previous study years. In 1979, total mean periphyton density in Corral Gulch (Stations 13 and 14) was intermediate to values observed in previous years. In Yellow Creek (Station 20 and 21) and White River (Station 27 and 29), mean densities were lower than that recorded in previous years.

At Station 13, Achnanthes minutissima was among the dominant taxa recorded for April 1979 as it was in previous years. In addition, Phormidium spp. and Fragilaria vaucheriae dominated in 1979 although they had not been reported as abundant in previous years. The periphytic algae that dominated in 1979

Table 4.5. Comparison of Mean Densities of the Most Abundant Algal Species (> 1% of Total Density) in the Periphyton During RBOSC MDP Studies. (April, 1978 and 1979), and RBOSC Aquatic Baseline Studies (April, 1975 and 1976).

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 13			
Achnanthes lanceolata	288	-	-	-
A. minutissima	4,661	14,765	94	905
Fragilaria vaucheriae	-	-	-	364
Bicoeca lacustris	-	631	162	-
Gomphonema intricatum	-	12,929	-	-
Meridion circulare	-	3,240	-	-
Navicula arvensis	-	-	25	-
N. crytocephala	830	2,081	14	-
N. pelliculosa	-	15,230	-	-
Nitzschia capitellata	-	1,008	-	-
N. frustulum	125	-	23	-
Synedra famelica	-	-	-	78
Phormidium spp.	-	-	-	3,148
Total Density[1]	6,334	52,868	403	4,633

Table 4.5. (Continued)

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 14			
Achnanthes lanceolata	247	-	-	160
A. minutissima	4,954	573	-	5,735
Biocoeca lacustris	-	3,471	-	-
Cymbella affinis	199	-	-	-
Gomphonema angustatum	-	-	-	274
Gomphonema intricatum	-	180	300	-
Navicula arvensis	199	177	584	2,590
N. cryptocephala	435	339	363	-
N. pelliculosa	-	957	607	315
N. secreta var. apiculata	-	-	-	200
N. viridula	168	-	-	-
Nitzschia capitellata	-	294	1,642	-
N. denticulata	1,688	-	-	-
N. frustulum	1,069	-	431	-
N. palea	171	-	-	-
Synedra amphicephala	135	-	-	-
S. famelica	-	-	-	162
S. fasciculata	-	-	-	111
Total Density[1]	9,929	6,538	4,176	10,163

Table 4.5. (Continued)

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 20			
Achnanthes minutissima	1,337	-	6,226	-
Cymbella affinis	63	-	-	-
Fragilaria vaucheriae	108	-	-	262
Gomphonema olivaceum	-	-	-	35
Navicula pelliculosa	518	1,334	21,965	729
Nitzschia capitellata	-	190	-	-
N. fonticola	-	-	-	232
N. frustulum	-	-	1,635	-
N. holsatica	-	80	-	475
N. microcephala	-	-	355	-
N. palea	45	-	909	-
N. spp.	-	-	-	29
Surirella ovata	243	1,035	-	280
Synedra amphicephala	-	1,350	-	-
S. famelica	-	-	-	26
Total Density[1]	2,439	4,287	31,436	2,182

Table 4.5. (Continued)

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 21			
Achnanthes lanceolata	-	-	-	8
Achnanthes minutissima	977	114	807	19
Fragilaria vaucheriae	162	118	-	106
Gomphonema olivaceum	-	-	-	11
Navicula cryptocephala	-	-	-	10
Navicula pelliculosa	3,996	547	15,634	75
Nitzschia capit llata	-	283	-	-
N. fonticola	-	-	-	25
N. frustulum	40	-	851	15
N. holsatica	-	136	-	52
N. microcephala	-	-	172	-
N. palea	58	-	1,791	-
N. spp.	-	-	-	9
Surierella ovata	266	1,276	219	124
S. ovalis	-	-	-	54
Synedra amphicephala	-	1,149	-	-
Total Density[1]	5,645	2,026	19,625	543

Table 4.5. (Continued)

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 27			
Achnanthes minutissima	-	-	-	40
Amphora ovalis var. pediculus	-	1,632	-	-
Cymbella minuta	-	-	-	19
Epithemia sorex	911	1,371	-	110
Gomphonema olivaceum	675	-	2,945	292
Navicula cryptocephala	2,329	1,144	401	-
N. cryptocephala var. veneta	-	-	-	44
N. pelliculosa	-	-	1,951	35
N. tripunctata	1,463	816	26	-
N. viridula	2,767	4,477	403	44
Nitzschia dissipata	1,957	1,519	259	29
N. fonticola	-	-	-	16
N. frustulum	-	997	-	15
N. holsatica	-	-	-	15
Rhoicosphenia curvata	-	-	-	19
Surirella ovata	540	-	-	-
Calothrix spp.	-	1,020	-	-
Phormidium spp.	-	-	-	143
Total Density[1]	13,790	14,604	6,155	885

Table 4.5. (Continued)

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 29			
Achnanthes lanceolata	-	-	-	3
Achnanthes minutissima	731	-	23	104
Amphora ovalis var pediculus	-	874	3	-
A. perpusilla	-	-	-	3
Cocconeis placentula	-	-	-	2
Cymbella sinuata	-	180	-	-
Epithemia sorex	1,192	117	-	-
Fragilaria vaucheriae	-	-	-	5
Gomphonema olivaceum	574	1,115	1,768	15
Navicula cryptocephala	889	540	545	-
N. cryptocephala var. veneta	-	-	-	2
N. pelliculosa	-	-	1,977	28
N. tripunctata	292	204	78	-
N. viridula	1,204	2,737	560	13
Nitzschia dissipata	1,474	986	590	-
N. fonticola	-	-	-	3
N. frustulum	101	187	103	-
Surrirella ovata	-	243	3	-
Calothrix spp.	157	-	-	-
Lyngbya spp.	259	-	-	-

Table 4.5. (Continued)

Taxa	Density (Units/mm^2) 1975	1976	1978	1979
	Station 29			
Plectonema spp.	250	-	-	-
Total Density[1]	9,294	7,647	5,740	193

[1] Total density figure also includes density estimates of less abundant periphyton not listed in the table.

Table 4.6. Comparison of Mean Periphyton Biomass (Ash-Free Dry Weight) During RBOSC MDP Studies (April, 1978 and 1979) and RBOSC Aquatic Baseline Studies (April, 1975 and 1976).

Station	Biomass (mg/cm^2) 1975	1976	1978	1979
13	1.018	2.594	0.696	1.737
14	27.182	1.234	2.940	0.992
20	1.484	0.846	1.572	0.783
21	2.136	0.754	6.008	1.641
27	8.862	6.486	1.040	2.465
29	6.936	2.330	1.124	0.694

are common in this region and characteristic of waters of high alkalinity, high dissolved oxygen, and medium organic load where oxidation is proceeding (Lowe 1974). The periphyton that dominated at Station 13 in previous years are characteristic of the same sort of environment but with perhaps a slightly lower organic load.

At Station 14, Achnanthes minutissima and Navicula arvensis dominated the samples. Both these taxa were reported as abundant or dominating in 1975 and 1976. The 1978 community at Station 14 was dissimilar with several abundant species unobserved in the 1979 samples. The environmental conditions indicated by the periphyton in 1979 were the same as that described for Station 13, but with a slightly lower organic load (Lowe 1974).

At Stations 20 and 21 in Yellow Creek where periphyton density was low, diversity was rather high. Fragilaria vaucheriae, Navicula pelliculosa, Nitzschia holsatica, and Surirella ovata were among the abundant taxa in April 1979. These taxa were observed as abundant or dominant in previous sampling years also. They are characteristic of waters with high alkalinity and medium-low organic load (Lowe 1974). Surirella ovata is reported to have its best development at low water temperatures. Its abundance may indicate a cold water condition prior to time of sampling.

At Stations 27 and 29 in the White River, diversity was relatively high. The dominant taxa at these two stations included Gomphonema olivaceum, Navicula pelliculosa, and Navicula viridula. In addition, Epithemia sorex and Phormidium spp. at Station 27 and Achnanthes minutissima at Station 29 were abundant. These are all characteristic of alkaline waters with a medium-low organic load as with the other sampling stations (Lowe 1974).

Biomass values for April 1979 were generally low. No trends were readily apparent when compared to previous biomass data for April. However, the White River station downstream from the confluence with Yellow Creek (Station 29) has had generally lower biomass values than the upstream station (Station 21).

Large spring-time fluctuation in maximum flow and changes in water temperature

may be primary factors in the observed variation. High waters tend to have a scouring effect on periphyton communities; the result is reduced densities. The physical data for April 1979 did indicate a much higher volume of flow at all sites than in previous years probably due to increased run-off from a large snowpack. Conversely, low flow and warm water promote growth of periphyton.

In summary, periphyton densities and biomass were generally lower at sampling stations during April 1979 than in previous April samples. This may be accounted for in large part, by the increased volume of water observed at all sites and a concomitant decrease in the size of periphyton communities caused by scouring. The only discernible trend in April data occurred in the White River where biomass and density appeared to be lower below than above the confluence with Yellow Creek as indicated by comparison of Station 27 and 29 data.

B. Benthos

1. Objectives

Benthic macroinvertebrates constitute the major component of the secondary trophic level in aquatic ecosystems on and near Tract C-a. Their limited mobility and well-documented susceptibility to physical and chemical changes in their environment make them an important element of the MDP Monitoring Program. Data collected on benthos species composition, relative abundance, and diversity at all sampling stations will permit the evaluation of development activity on benthos as well as identification of potential impacts on other components of the aquatic system.

2. Methods

Three replicate macroinvertebrate samples are collected with a Modified Hess Sampler at each sampling site during each sampling period. The Modified Hess Sampler is a lightweight, shallow-water benthos sampler suitable to yield quantitative results in rubble and gravel substrates. The sampler, modified

from the original Surber square-foot sampler described by Waters and Knapp (1961), is elliptical (or cylindrical) in shape, and consists of a metal frame with #30 mesh (0.6 mm aperature) side curtains. The side screening prevents capture of drifting organisms. A screened cone attached to the downstream side of the sampler funnels organisms into a collection bag.

At time of collection, samples are washed into a bucket fitted with a U.S. Standard #30 sieve and flushed with water. The contents are then preserved with 10 percent formalin for transport to the laboratory.

In the laboratory, the benthic samples are washed thoroughly with a fine spray through a U.S. Standard #60 sieve to remove fine sediments. Samples are systematically searched with a dissecting scope at 10 X magnification and macroinvertebrates removed from the debris. Sorted samples are stored in a 70 percent ethyl alcohol glycerin solution until species identification.

All organisms, with the exception of the groups Oligochaeta and Chironomidae, are counted and identified with a dissecting microscope (10-40 X magnification). The groups, Oligochaeta and Chironomidae, are mounted in glycerin on slides and identified with a compound microscope (100-1,000 X magnification). All individuals are identified to the lowest taxon feasible. Only those individuals living at the time of collection, as indicated by the presence of fleshy tissue, are counted.

All data are recorded on specially developed data forms. Organisms are identified primarily by use of taxonomic keys provided by Usinger (1956), Edmondson (1959), Wiggins (1977), Mason (1973), Beck (1975, 1976), and Brinkhurst (1970).

Specimens of each taxon are preserved and included in the voucher collection. Permanent slides of representative individuals of Chironomidae and Oligochaeta taxa are made by clearing in xylene and then mounting in Canada balsam.

Densities of taxa identified at each sampling location are determined from count data using the following formula:

$$D = N \times \frac{S}{10,000}$$

where: D = density (#'s/m^2)
N = number of individuals of taxon counted
S = size of sampling device (cm^2)
10,000 = number of cm^2 in 1 m^2

3. Results and Discussion

Macroinvertebrate data collected during the April 1979 RBOSC MDP aquatic sampling program are presented in Appendix 4-2.2. Enumeration data and a list of taxa collected at each sampling site are provided in Appendices 4-2.2a and b. Macroinvertebrate densities for each sampling site are presented in Appendix 4-2.2c. A comparison of April 1979 macroinvertebrate density with those from previous April samples is provided in Table 4.7.

Macroinvertebrate densities were generally lower for Stations 13 and 14 (except for Oligochaeta at 14, Corral Gulch) in 1978 and 1979 than in previous April samplings. Station 13 demonstrated a low diversity with Oligochaeta and Chironomidae as the major groups present. Naididae was the major Oligochaeta group. Diamesa and Micropsectra were common Chironomidae genera.

Oligochaeta and Chironomidae were also the dominant groups at Station 14, yet there was a greater diversity of organisms than Station 13. Tubificidae was the major Oligochaeta group at Station 14, and these were found in higher numbers than previous years. Densities were lower for Chironomidae in 1979 than any of the previous years. Trichoptera (Ochrotrichia sp.) was a new group found at this site in 1979. Ephemeroptera (Baetis sp. and Ephemerella inermis) was found in 1979 and had not been found at Station 14 since 1976. Cardiocladius sp. was the most numerous Chironomidae, yet a total of 10 Chironomidae taxa was found in April 1979 at this site.

Station 13 is subject to variation in flow as well as an eroding substrate. This would explain the fact that virtually only Chironomidae and Oligochaeta

Table 4.7. Comparison of Major Benthic Macroinvertebrate Taxa Observed During RBOSC Aquatic Monitoring Studies (April, 1977, 1978, and 1979) and RBOSC Aquatic Baseline Studies (April, 1975 and 1976).

Taxa	Density (Mean Organism/m^2) 1975	1976	1977	1978	1979
	Station 13				
Nematoda	241	24	9	42	7
Oligochaeta	96	18	1,720	150	45
Ephemeroptera	2,685	139	63	-	-
Plecoptera	91	24	887	-	-
Coleoptera	-	-	55	6	-
Diptera[1]	476	24	82	12	7
Chironomidae	10,896	1,961	20,245	66	22
Total	14,485	2,190	23,061	276	81
	Station 14				
Nematoda	252	187	NS[2]	-	7
Oligochaeta	3,405	294	NS	994	1,553
Ephemeroptera	1,199	24	NS	-	19
Trichoptera	-	-	NS	-	26
Coleoptera	-	24	NS	126	-
Diptera	710	235	NS	66	26
Chironomidae	59,836	16,531	NS	3,270	680
Total	65,402	17,295		4,456	2,311

Table 4.7. (Continued)

Taxa	Density (Mean Organism/m^2) 1975	1976	1977	1978	1979
	Station 20				
Nematoda	145	320	371	289	-
Oligachaeta	627	2,353	154	222	13
Ephemeroptera	-	-	9	-	-
Plecoptera	-	-	9	-	-
Odonata	12	-	-	-	-
Diptera	4,158	102	105	3,165	91
Chironomidae	5,750	1,002	2,588	3,336	434
Total	10,692	3,777	3,236	7,012	538
	Station 21				
Nematoda	66	290	NS	114	-
Oligochaeta	18	271	NS	301	7
Ephemeroptera	6	-	NS	-	-
Plecoptera	6	-	NS	-	-
Coleoptera	-	54	NS	-	-
Diptera	1,641	344	NS	2,455	56
Chironomidae	5,279	754	NS	2,853	207
Total	7,016	1,713		5,723	270

Table 4.7. (Continued)

Taxa	Density (Mean Organism/m^2) 1975	1976	1977	1978	1979
	Station 27				
Nematoda	7	13	NS	19	-
Oligochaeta	477	59	NS	1,130	110
Ephemeroptera	280	1,698	NS	1,430	511
Plecoptera	13	78	NS	65	13
Trichoptera	-	72	NS	104	-
Diptera	-	-	NS	46	-
Chironomidae	516	558	NS	643	13
Total	1,293	2,478		3,437	647
	Station 29				
Nematoda	117	20	136	13	7
Oligochaeta	1,615	852	397	648	291
Dphemeroptera	742	605	5,077	480	615
Plecoptera	91	157	1,485	77	52
Trichoptera	189	14	806	71	-
Diptera	52	13	154	69	-
Chironomidae	1,331	46	1,166	39	20
Total	4,137	1,707	9,221	1,397	985

[1] Diptera other than Chironomidae

[2] Station not sampled

are able to exist, since they can tolerate habitat alterations. Station 14 has also had a great deal of habitat modification (from stream to pond), yet it has a slower flow as well as some areas of aquatic vegetation and deeper pools. Therefore, one would expect a greater diversity as well as the occurrence of Ephemeroptera and Trichoptera, which are more adapted to this pond-like habitat. Continual habitat modification may account for the generally lowered densities for Stations 13 and 14 in 1978 and 1979.

Stations 20 and 21 (Yellow Creek) showed a marked decrease in numbers of the major groups from all previous April sampling periods. Diversity was very low for both sites, with Chironomidae as the major group. Diamesa, Cardiocladius, and Orthocladius were the common Chironomidae taxa at this site. Other groups were virtually nonexistent in 1979, a marked contrast with other years. This area of Yellow Creek had a major flash flood and scouring in 1978, which may account for the low diversity and density.

The White River Stations 27 and 29 showed a decrease in both density and diversity, (except for Ephemeroptera at Station 29). No Nematoda or Trichoptera were found at site 27 and no Trichoptera were found at site 29 as in previous years. Ephemeroptera was still the major group in 1979. Baetis, Rhithrogena, Ephemerella, and Tricorythodes were the common Ephemeroptera genera; these are all standard river species. Trends in diversity and density for the White River for April, 1975 to 1979 show normal fluctuations due to velocity and flow changes.

In general, benthos samples from Stations 13, 14, 20, and 21 showed a decrease in the number of taxa and total numbers, possibly due to habitat modification and stream erosion. Samples from Stations 27 and 29 reflect a normal river fauna, though there is some decrease in density for 1979.

4.3 SUMMARY AND CONCLUSIONS

The physical parameters measured at each aquatic sampling station vary appreciably from year to year. The April 1979 measurements were within the range of previous years except for increased volume of water at all stations and an increase in conductivity and alkalinity and decrease in dissolved oxygen and pH at Station 14.

The water quality parameters analysed for the sampling stations on the White River changed very little from baseline conditions. No significant difference was found between the water quality above and that below the confluence with Yellow Creek.

Total mean periphyton density values varied from 10,163 units/mm^2 (of microscope field) at Station 14 in Corral Gulch to 193 units/mm^2 at Station 29 in White River in April, 1979. These values were generally lower than those of April samples in previous study years, but higher than those measured in 1978. In 1979, total mean periphyton density in Corral Gulch (Stations 13 and 14) was intermediate to values observed in previous years. In Yellow Creek (Station 20 and 21) and White River (Station 27 and 29), mean densities were lower than that recorded in previous years.

Biomass values for April 1979 were generally low. No trends were readily apparent when compared to previous biomass data for April. However, the White River station downstream from the confluence with Yellow Creek (Station 29) has had generally lower biomass values than the upstream station (Station 21).

In summary, periphyton densities and biomass were generally lower at sampling stations during April 1979 than in previous April samples. This may be accounted for in large part, by the increased volume of water observed at all sites and a concomitant decrease in the size of periphyton communities caused by scouring. The only discernible trend in April data occurred in the White River where biomass and density

appeared to be lower below than above the confluence with Yellow Creek as indicated by comparison of Station 27 and 29 data.

Benthos samples from Stations 13, 14, 20, and 21 showed a decrease in the number of taxa and total numbers of macroinvertebrates, possibly due to habitat modification and stream erosion. Samples from Stations 27 and 29 reflect a normal river fauna, athough there is some decrease in density for 1979.

LITERATURE CITED

Beck, W.M., Jr. 1975. Chironomidae, P. 159-180 In. F.K. Parrish (ed.) Keys to water quality indicative organisms of the southeastern United States. USEPA, Cincinnati, Ohio.

Beck, W.M., Jr. 1976. Biology of the larval Chironomids. State of Florida, Dept. Environmental Regulation, Tech. Ser. 3(1):1-58.

Brinkhurst, R.O. and B.G.M. Jamieson. 1970. Aquatic Oligochaeta of the World. Univ. Toronto Press, Toronto. 860 pp.

Edmondson, W.T. (ed.) 1959. Freshwater Biology. John Wiley and Sons, Inc., N.Y. 1,248 pp.

Margalef, R. 1974. Counting. Pages 7-13 In. R. Vollenweider. 1974. A manual on methods for measuring primary production in aquatic environments IBP Handbook Number 12, Second Edition. Blackwell Scientific Publications, Condon. Section 2.12.

Lowe, R.L. 1974. Environmental requirements and pollution tolerance of freshwater diatoms. U.S. Environmental Protection Agency. Environmental Monitoring Series EPA -670/4-74-005. 334 pp.

Mason, W.T. 1973. An introduction to the identification of Chironomid larvae. USEPA, Cincinnati, Ohio.

Usinger, R.L. 1956. Aquatic Insects of California with Keys to North America Genera and California Species. Univ. of California Press. 508 pp.

Waters, T.F. and R.J. Knapp. 1961. An improved stream fauna sampler. Transactions of the American Fisheries Society. 90(2):225-226.

Wiggins, G.B. 1977. Larvae of the North American Caddisfly Genera (Trichoptera). Univ. Toronto Press. 401 pp.

SECTION 5
HYDROLOGY STUDIES

During this initial period of oil shale development on Tract C-a, Rio Blanco Oil Shale Company has conducted two programs to measure the effects of mining activity upon surface and groundwater quality and quantity: 1) the environmental hydrologic monitoring program, and 2) the operational hydrologic monitoring program. The activities whose effects have been measured include upper aquifer dewatering, injection of upper aquifer water back into the upper aquifer and discharge of upper aquifer water into surface streams, earth-moving activities associated with the support facilities of the mine, road construction, and other miscellaneous discharges. These activities have only secondary, minor impact upon the hydrologic regime. Retorting of MIS retorts will not begin for approximately one year.

In general, the environmental hydrologic program is conducted at a distance from the mining activities. During the baseline and subsequent monitoring periods, surface water data have been collected from six springs and seeps and six surface water gaging stations. Groundwater data have been collected from 10 alluvial monitoring holes, 16 upper aquifer holes, and one lower aquifer hole (see Map 1, Map Pocket).

The bulk of the operational hydrologic monitoring data is collected on-tract. These data include the quantification of mine water discharges, reinjection, and dewatering. Sites monitored regularly under the operational program include five surface water sites, composite reinjection water, discharged water, eight alluvial holes, six upper aquifer holes, one lower aquifer hole, and 10 erosion-sedimentation sites (see Map 1, Map Pocket). These data, collected in compliance with permit stipulations or special test monitoring, are reported on a regular basis and are not included herein. Other sites are monitored, as necessary, to provide additional operational dewatering data or special test data. The results of these studies are incorporated into various reports and plans and are not repeated in this report. However, information gained during these special tests is used to evaluate the effects of tract development on the hydrologic regime, and pertinent data will be presented, as appropriate, in the year-end report.

This report covers the environmental hydrologic data collected and received during the period of December 1978 through May 1979. It presents the second

detailed statistical analysis of data since the Final Environmental Baseline Report, and the first since the Year-End Report (December 1977-November 1978).

5.1. SURFACE WATER

A. Streams

1. Objectives

The objective of the surface water monitoring is to determine if surface water quality and quantity are affected by the Tract C-a MIS mining activities and the construction of associated facilities.

2. Methods

The methods of hydrology data collection were described in RBOSC MDP Monitoring Report 1 and are not repeated herein. Environmental Sampling Sites Map 1 (see Map Pocket) shows the locations of the USGS gaging stations.

3. Results and Discussions

a. Physical Parameters - Table 5-1 is a surface gaging station flow and sampling summary for the reporting period covered by this report. In the baseline study, gages at each of the stations recorded some flow. During the period December 1978 through May 1979, flow was not recorded in Rinky Dink Gulch and Dry Fork. The stations at Corral Gulch east and west of Tract C-a recorded continuous flow throughout the study period. The Yellow Creek station reported continuous flow except during December and January.

Table 5-1 also shows the months during which water quality samples were taken and the drainage area of each basin.

Data for water year 1979 (October 1978 to September 1979) are limited to October through April and, for some stations, to March, 1979 because data are not available from the USGS. A comparison of monthly flows for the first half of the water year 1979 with the flows of water years 1975-1978 (Figures 5-1, 5-2, and 5-3) shows that all reporting stations except Yellow Creek near the White River have flow patterns similar to those recorded in earlier water

Table 5-1. Surface Gaging Station Flow and Sampling Summary for the Reporting Period, Tract C-a

Location	1978	1979				
	Dec	Jan	Feb	Mar	Apr	May
Dry Fork near West Line Tract C-a (09306237) [2.91]	0	0	0	0	0	
Corral Gulch near West Line Tract C-a (09306235) [8.44]	X S	X S	X S	X S	A S	A
Box Elder Gulch near West Line Tract C-a (0936240), [10.29]	0	0	0	0	I	A
Corral Gulch East of Tract C-a (09306242) [29.59]	X S	X S	X S	X	X S	A
Yellow Creek near White River, Colo. (09306255) [262.00]	I S	I S	X S	X S	A S	A
"Rinky Dink" Gulch near East Line of Tract C-a (09306241) [2.25]	0	0	0	0	0	A

X - Flow recorded during entire month
I - Intermittent flow recorded during month
S - Water quality sample collected during month
0 - No flow recorded during month
A - Data not available
[] - Drainage area in square miles

years. However, the magnitude of flows in Corral Gulch East is higher because of surface discharge from mine dewatering activities.

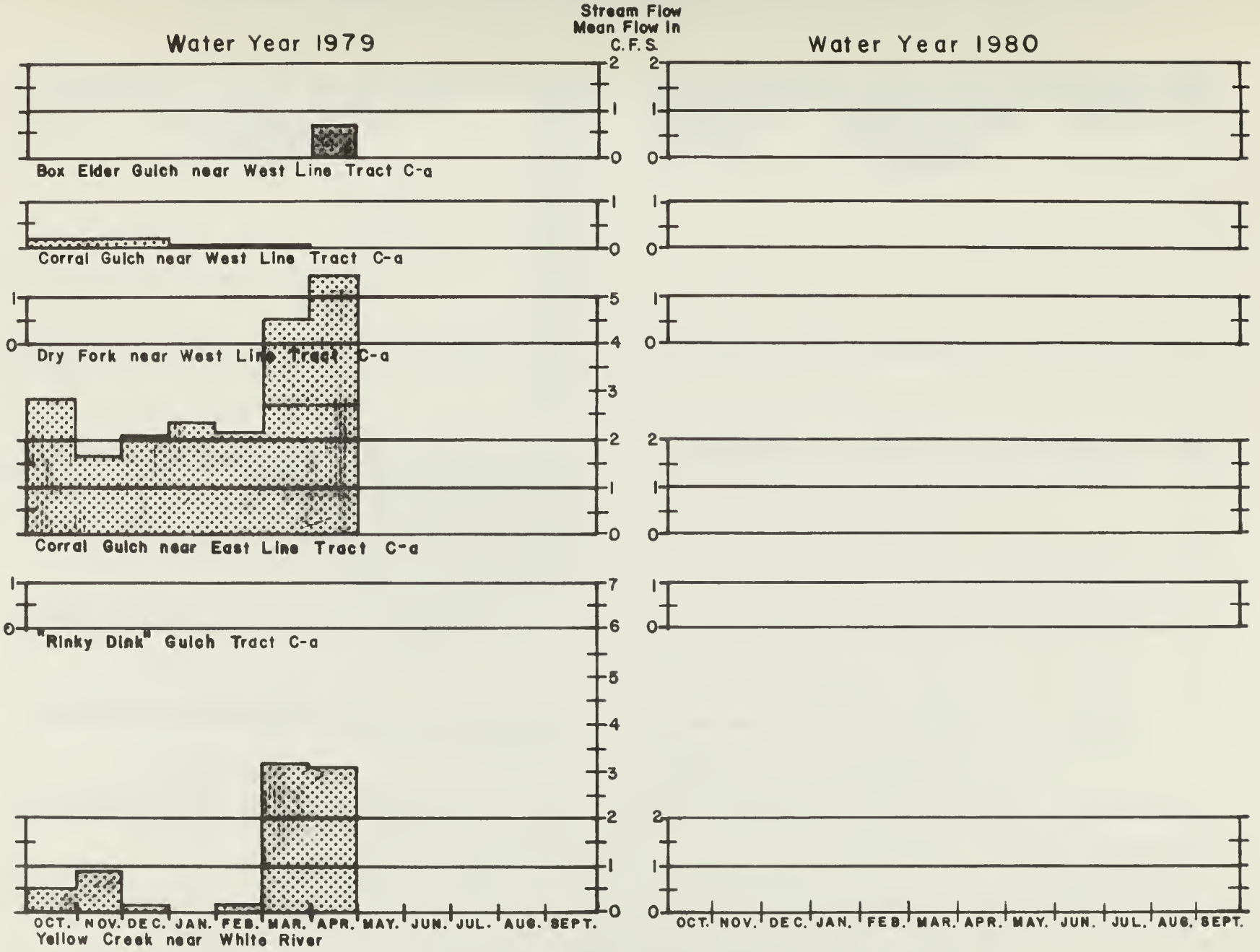

Water Year 1979
Stream Flow
Mean Flow in
C.F.S.
Water Year 1980
Box Elder Gulch near West Line Tract C-a
Corral Gulch near West Line Tract C-a
Dry Fork near West Line Tract C-a
Corral Gulch near East Line Tract C-a
"Rinky Dink" Gulch Tract C-a
Yellow Creek near White River
OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEPT.

Figure 5-1. Monthly Mean Flows at Six USGS Surface Water Gaging Stations, Water Year 1979 (Oct-Apr)

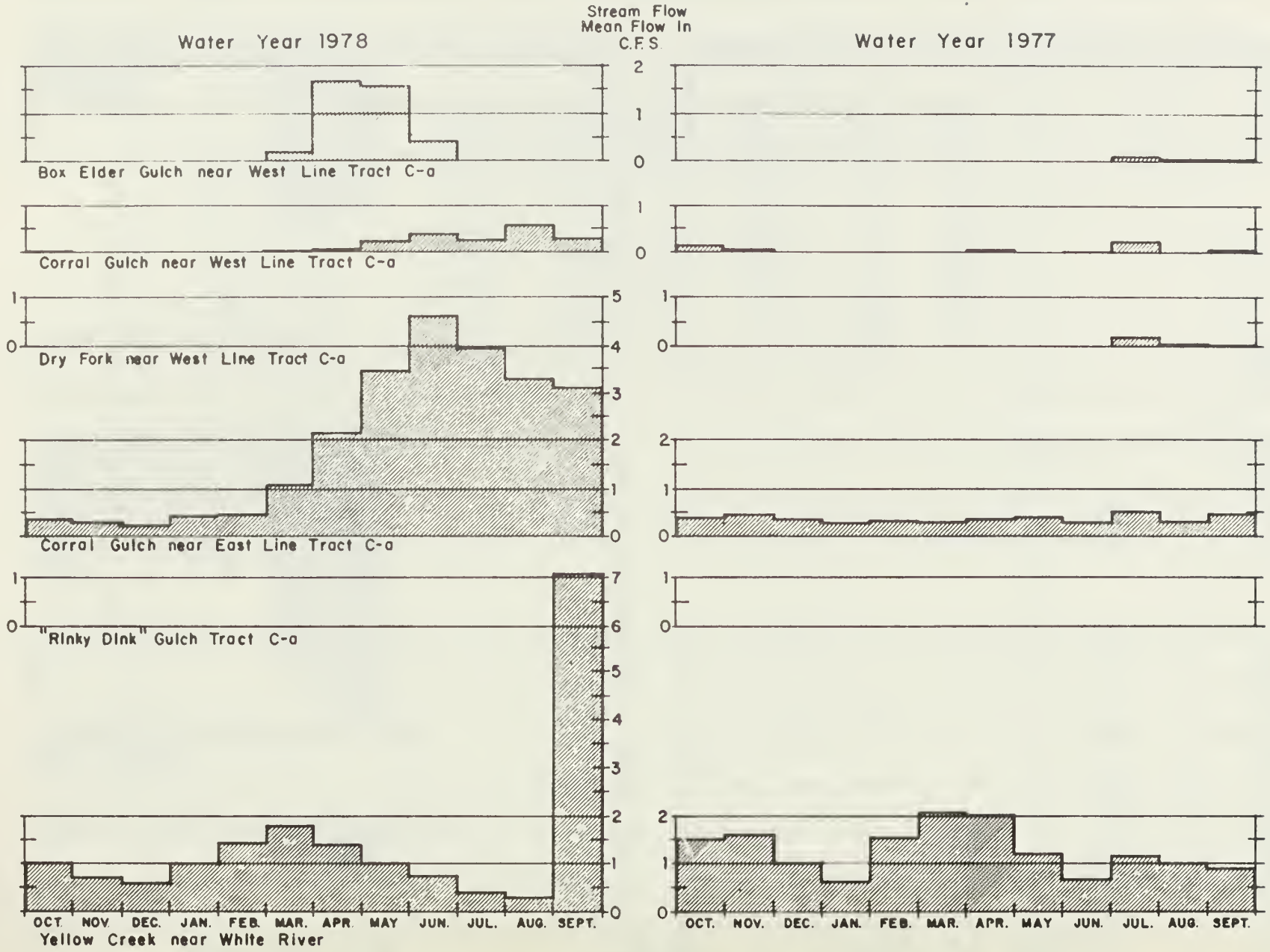

Water Year 1978
Stream Flow
Mean Flow In
C.F.S.
Water Year 1977
Box Elder Gulch near West Line Tract C-a
Corral Gulch near West Line Tract C-a
Dry Fork near West Line Tract C-a
Corral Gulch near East Line Tract C-a
"Rinky Dink" Gulch Tract C-a
Yellow Creek near White River
OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT.

Figure 5-2. Monthly Mean Flows at Six Surface Water Gaging Stations, Water Years 1977 and 1978

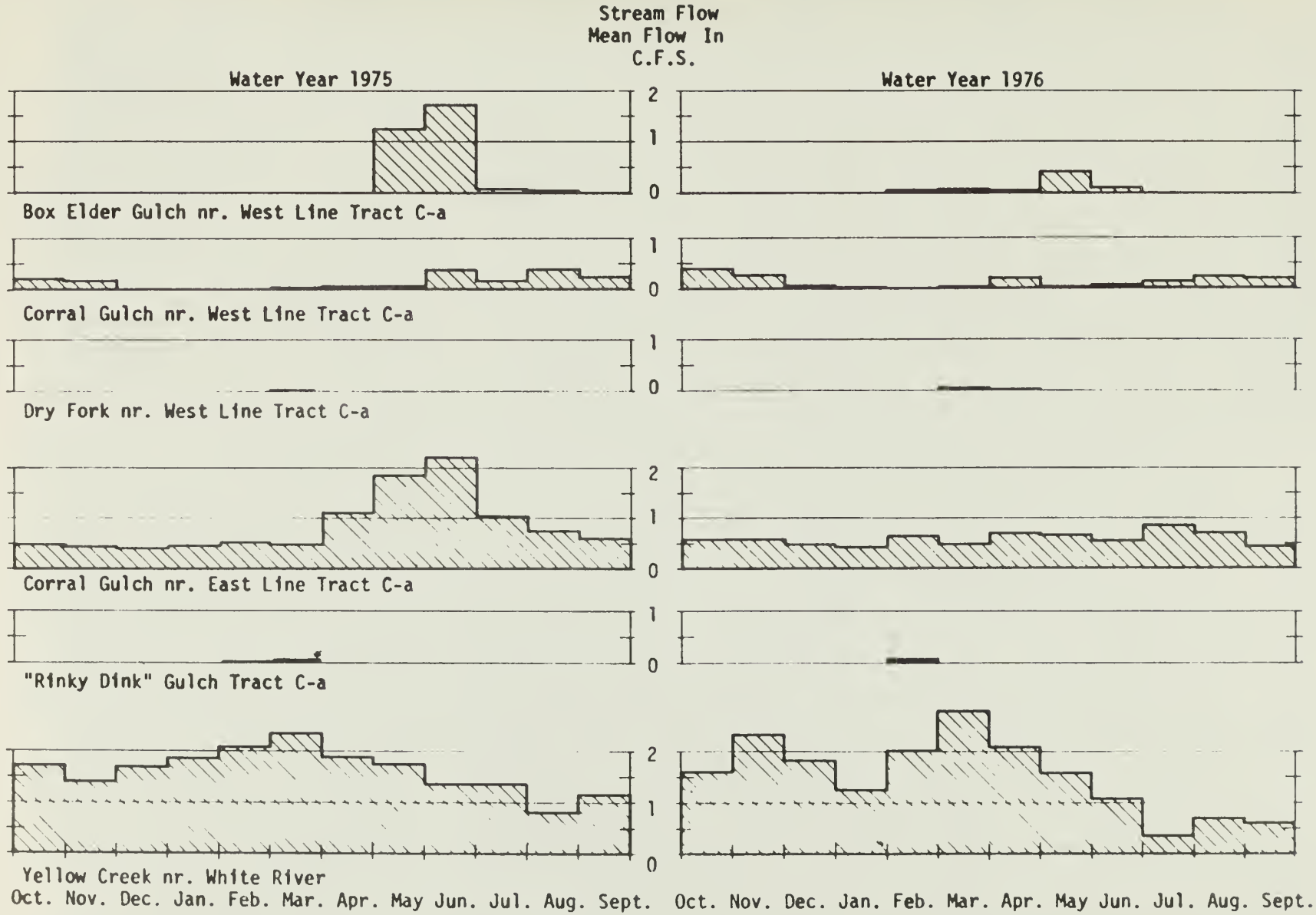

Stream Flow
Mean Flow In
C.F.S.
Water Year 1975
Water Year 1976
Box Elder Gulch nr. West Line Tract C-a
Corral Gulch nr. West Line Tract C-a
Dry Fork nr. West Line Tract C-a
Corral Gulch nr. East Line Tract C-a
"Rinky Dink" Gulch Tract C-a
Yellow Creek nr. White River
0
1
2
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept.
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept.

Figure 5-3. Monthly Mean Flows at Six Gaging Stations, Water Years 1975 and 1976.

The reduced flow during October through February at the Yellow Creek station is probably related to lower than average temperatures throughout the winter of 1978-1979, which caused snow to accumulate rather than melt.

Table 5-2 summarizes the annual runoff in acre-feet from 1975 to 1979. Water year 1977 showed the effects of the drought at all the stations except Dry Fork, which did not suffer a reduction in runoff until 1978. The 1978 increase in runoff at Corral Gulch West and Box Elder Gulch stations represented a return to more normal flows. Downstream of the dewatering activities, at the Corral Gulch East gaging station, however, the annual runoff increased from a maximum of 626.2 acre-feet during the baseline period to 1,399 acre-feet in 1978 and 1,285 acre-feet for the first seven months of water year 1979 (Table 5-2). This increase in total runoff was caused by the shut-down of the injection well system in late February 1979 for testing purposes and the subsequent discharge of all water produced from dewatering into Corral Gulch (Figure 5-4). Increased flows to date represent a 60 percent increase in runoff as a result of mine dewatering.

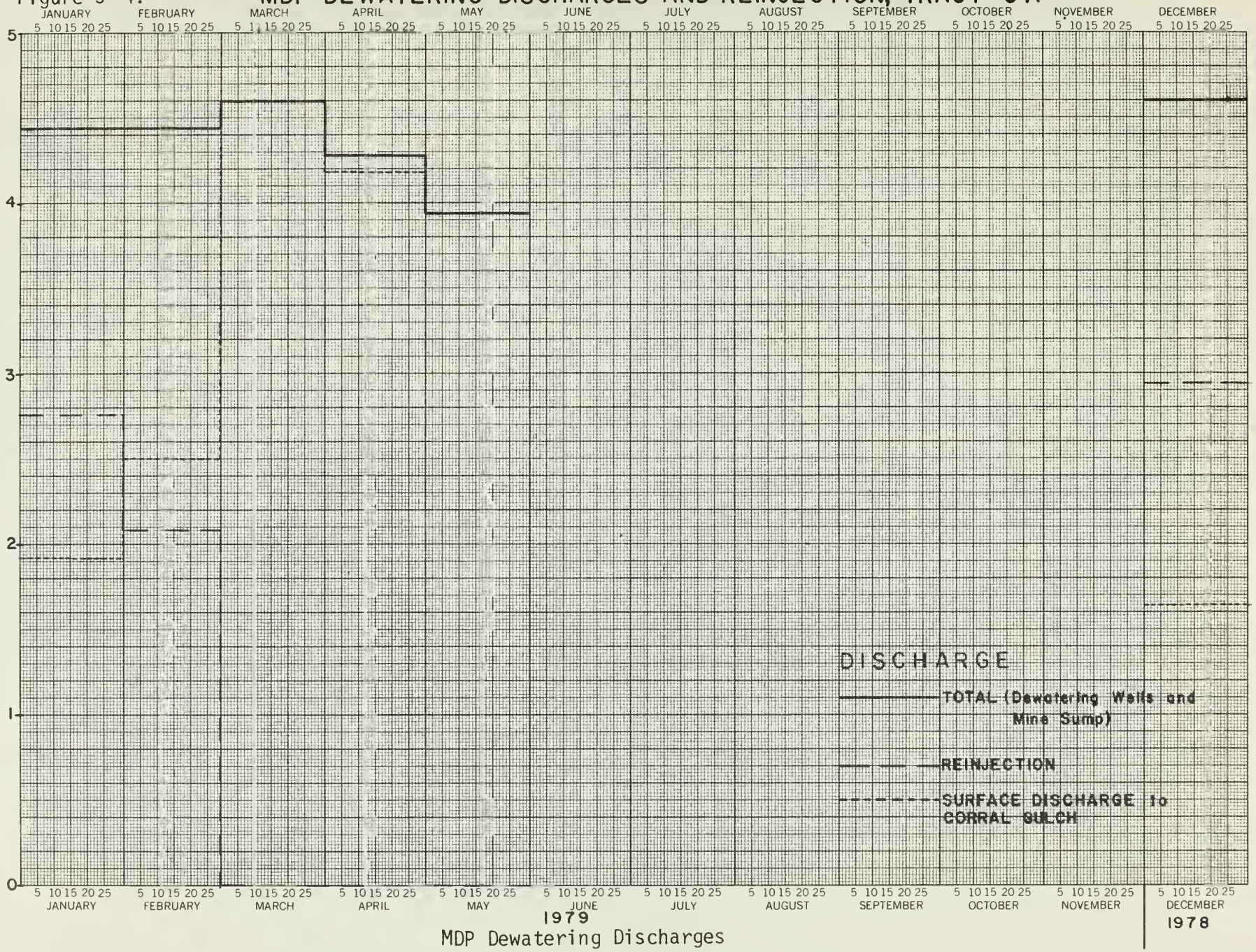
In order to determine the difference between the amount of water entering Tract C-a and the amount leaving Tract C-a via the surface, the sum of in- flows from Dry Fork, Box Elder Gulch, and Corral Gulch West were subtracted from the outflow at the Corral Gulch East gaging station. The results of this calculation indicate that during the period of October 1978 through March 1979, inflow approximately equalled outflow.

The continued high flows of water across the tract are caused by the discharge of dewatering water into the Corral Gulch drainage (Figure 5-5). The peak in March 1979 was due to the injection well shut-down and subsequent increase in surface discharge in late February.

b. Chemical Parameters - Summaries of water quality data collected at Corral Gulch near the west line of Tract C-a, Corral Gulch near the east line of Tract C-a, and Yellow Creek near the White River for the period of December 1978 through May 1979 are presented in Appendix 5-1.1. As shown in Table 5-2, no flow was recorded at the Dry Fork, Box Elder, or Rinky Dink gaging stations. Individual sample analyses are included in Appendix 5-1.2.

Figure 5- 4.

MDP DEWATERING DISCHARGES AND REINJECTION, TRACT C-A



MDP Dewatering Discharges

Figure 5-5. Comparison of Surface Water Inflows and Outflows 1974-1979, Tract C-a.

Table 5-2. Annual Runoff in Acre-Feet, Tract C-a and Vicinity

STATION	WATER YEAR 1975	WATER YEAR 1976	WATER YEAR 1977	WATER YEAR 1978	WATER YEAR 1979
Dry Fork near west line Tract C-a (09306237)	0.2	4.3	11.4	Dry	Dry (Oct-Apr)
Corral Gulch near west line Tract C-a (09306235)	96.7	98.5	30.8	107.1	50.3 (Oct-Mar)
Box Elder Gulch near west line Tract C-a (09306240)	182.8	34.8	13.9	228.4	47.8 (Oct-Apr)
Corral Gulch near east line Tract C-a (09306242)	626.2	418.1	262.8	1399	1285 (Oct-Apr)
Yellow Creek near White River (09306255)	1158.7	1103.1	925.7	1044.6	316.66 (Oct-Mar)
Rinky Dink Gulch near east line Tract C-a (09306241)	0.6	2.3			

In order to identify impacts on the hydrologic system caused by tract development, RBOSC has made the commitment to increase the scope and intensity of monitoring whenever certain "triggers" are exceeded. However, inherent variability in physical and chemical constituents in the hydrologic regime make it difficult to separate development-related changes from natural variations. RBOSC believes, in many cases, that the "triggers" identified in the monitoring program and conditions of approval are too sensitive. In order to verify this hypothesis, RBOSC completed some special "mid-year" statistics to test the stated null hypotheses and to determine whether or not variations in hydrologic parameters measured to date (prior to retort burning) are significant; whether these variations represent development impacts or merely natural variations; and whether or not the dewatering activities alone, in the absence of major development, could produce significant variations in water quality.

The null hypothesis (there is no significant difference between the chemical composition of the surface water reported in the baseline data and the chemical composition of the surface water reported in the MDP data) was tested using the baseline data as the control group and the MDP data as the treatment group.

The means of the control group and the treatment group were tested to determine whether there is any significant difference between them or whether the difference is merely due to chance. The t- and F-tests, whose formulae are given in Appendix 5-2.6 were used to compare these means. The calculated t was then compared with a tabular value of t at the .025 level. Since a two-tailed t-test was used, the overall significance level is .05. If the calculated t had an absolute value less than the tabular value, the null hypothesis was accepted. However, if the calculated value was larger than the tabular value, then the null hypothesis was rejected and an anomaly indicated. The anomaly was then analyzed to determine its possible source.

These tests indicated that 11 chemical constituents were signficantly different during the MDP from baseline values at one or more stations. Table 5-3 shows the constituents at Corral Gulch East, Corral Gulch West, and Yellow Creek gaging stations whose means showed a statistically significant difference at the 95 percent confidence level. Of the 14 significant differences identified, 7 represent decreased values for that constituent and 7 represent increased values.

The restriction of this reporting period to the winter and early spring months greatly affect the comparability of these data to the baseline. This probably explains the various anomalies indicated for the Yellow Creek and Corral West stations. The anomalies for the Corral Gulch East gaging station appear to be related to the addition of upper aquifer water to the water type recorded and identified during the baseline period. However, since the change in water quality was significant for the 11 constituents, the null hypothesis had to be rejected.

The rejection of the null hypothesis on the basis of these analyses must be examined in further detail to evaluate its validity and scientific importance. Firstly, comparison of six months' worth of data against a two-year baseline

TABLE 5-3. Student's t-Test Results, Indicating Those Constituents Which Were Significantly Different in a Comparison of Baseline Data and MDP Data, December 1, 1978 - May 31, 1979

	Yellow Creek (09306255)	Corral West (09306235)	Corral East (09306235)
Calcium			-
Chloride			+
Fluoride			
Magnesium	-		+
Potassium	+		-
Silica			+
Sodium			+
Sulfate	-	-	+
pH			
Conductivity			+
Temperature		-	-

\+ indicates mean from MDP greater than mean from baseline
\- indicates mean from MDP less than mean from baseline

mean may have introduced a seasonal bias into the analysis which indicates a "significant difference" not truly reflective of the field situation. Secondly, these "significant differences" may merely represent natural variations in the hydrologic regime or sampling errors which are not related to development activities. Thirdly, one must assess the nature of the differences. Do the differences represent increases or decreases in chemical concentrations or physical parameters? Does the difference improve, degrade, or have no effect on "water quality"? Is the magnitude of the change large enough to affect the biotic component? Is the effect, if it occurs, of biological significance? These questions, of course, have no ready answers and must await additional data and analysis at the end of the reporting year.

In consideration of these arguments, RBOSC feels that rejection of the null hypothesis at this time does not necessarily reflect a source of development impact. The rejection may be the result of one or more of the following: 1) seasonal bias, 2) natural variation, 3) discharge of upper aquifer water, or 4) overly strict statistical limitations of these tests. This situation will be watched closely and evaluated again in the year-end report.

U.S. Geological Survey suspended-sediment discharge data for water year 1978 are included in Appendix 5-1.3. A single large event of 290,000 tons/day was recorded on the 7th of September 1978 at the Yellow Creek Station, number 09306255. This event was not recorded at the Corral Gulch east station, suggesting it was an isolated precipitation event which occurred several miles downstream of Tract C-a, and was, therefore, not related to Tract activities.

B. Springs and Seeps

1. Objectives

The objective of monitoring and observing major springs and seeps during the MDP is to determine if spring and seep flows and conductivities are affected by mining and operation activities.

2. Methods

The methods followed for collection of these data were described in RBOSC MDP Monitoring Report 2 and are not repeated herein.

3. Results and Discussion

Table 5-4 presents a summary of the data collected from the springs and seeps during the current reporting period. Map 1 (Map Pocket) shows springs and seep locations. All of the springs and seeps were inaccessible during January because of the snow pack. Cathedral Bluffs was also inaccessible during April because of snow. Flow could not be measured at Stake Springs Draw (5), Box Elder Gulch (8), and 84 Ranch (14) because of high runoff. For the same reason, a sample could not be collected at Box Elder Gulch (8).

Table 5-5 compares the maximum and minimum conductivity readings from the baseline to those data collected during the MDP period. None of the values were noted to have changed by more than 20 percent, with the exception of the conductivity at Spring and Seep No. 14. This new high reading of 2,700 micromhos per centimeter, recorded in April 1979, was caused, in part, by stagnation of the normal flow from this spring. Since the major road was widened and the

Table 5-4. Summary of Spring and Seep Sampling Schedule and Flow, Tract C-a

Spring Name and Location Number	1978 Dec	1979 Jan	Feb	Mar	Apr	May
1 Cathedral Bluffs		I			I	
2 Spruce Gulch		I			S,X	
3 Maverick Spring		I			S,X	
5 Stake Springs Draw		I			S,C	
8 Box Elder Gulch		I			C	
14 84 Ranch		I			S,C	

X - Flow recorded at time of collection
S - Sample collected
I - Inaccessible
D - Dry
C - Flow obscured by runoff water; flow could not be measured and/or sample could not be collected.

Table 5-5. Comparison of Baseline and MDP Conductivity Data for Springs and Seeps, Tract C-a

Location	Baseline Maximum	Baseline Minimum	MDP
Spring or Seep 1	950	825	---
Spring or Seep 2	1200	1000	1120
Spring or Seep 3	1300	850	1300
Spring or Seep 5	1500	1300	1280
Spring or Seep 8	1100	850	---
Spring or Seep 14	2000	1550	2700

Springs 1 and 8 were inaccessible

main channel re-routed, the normal flow from this spring has appeared to be partially blocked, resulting in ponding and subsequent concentration due to evaporation.

Physical parameters measured during April 1979 at the springs and seeps are summarized in Table 5-6.

The evidence that the conductivity of Spring number 14 rose because of a stagnation process illustrates that the 20 percent triggering mechanism may be too stringent. Had the triggering mechanism been in effect during the monitoring period, additional monitoring would have been required for Spring 14.

Table 5-6 Flow, Conductivity, pH, and Temperature for Springs and Seeps During April 1979, Tract C-a

Spring Number	Flow (cfs)	Conductivity (umhos)	pH	Temperature (°C)
1	Inaccessible- - - -

5.2 GROUNDWATER

A. Alluvial Aquifers

1. Objectives

The purpose of monitoring the alluvial aquifers during the MDP is to detect changes in the character of the alluvium, determine if the changes are significant, and analyze the changes to ascertain if they are caused by mining or development operations, such as accidental oil spills, breakthrough of the injection water into the lower aquifer, or releases of dewatering water into the alluvial aquifers. An additional objective is to determine if lease and permit requirements are being followed.

2. Methods

The methods used to collect and analyze these data were described in the RBOSC MDP Monitoring Report 2 and in the 1977-1978 Year-End Report and are not repeated herein.

3. Results and Discussion

a. Physical Parameters - During the baseline program, three of the original seven alluvial wells (G-S S6, G-S S13, and G-S S14) were dry. Of the additional new wells, G-S S25 and G-S S26 were also dry. These five wells remained dry during the reporting period. Table 5-7 indicates the months during which data were taken and lists the wells included in the program. The physical data collected during the baseline are summarized in Table 5-8. Figure 5-6 illustrates the method of completion of each hole. Table 5-9 indicates the depth of each hole to the perforated interval. Water level, temperature, conductivity and pH data for the holes monitored during the reporting period are shown in Figures 5-7 through 5-27.

Temperature, pH, and conductivity data collected during March 1979 showed definite variations which were correlated with the use of different equipment by tract and Wright Water Engineers (WWE) personnel. The conductivity

Table 5-7. Alluvial Well Monitoring Summary

Well #	1978 Dec.	1979 Jan	Feb	Mar	Apr	May
G-S S6	D	D	D	D	D	D
G-S S7	P L	X L	P	P L	P B	P L
G-S S8	P	X		P	P	P
G-S S11	P	X	C,P L	C,P L	C,P B	C,P L
G-S S11a	P	X	P,D_a	P,D_a	P,D_a	P,D_a
G-S S11 (Shallow)	D	D	D	D	D	P
G-S S11a (Shallow)	D	D	D	D	D	P L
G-S S13	D	D	D	D	D	D
G-S S14	D	D	D	D	D	D
G-S S24	P		P,D_a L	P,D_a L	P,D_a B	P,D_a L
G-S S26	D	D	D	D	D	D
G-S S27	P L	X L	C,P L	C,P L	C,P B	C,P L
G-S S27a	D	D	D	D	D	D

X - At least one water level
L - Limited water quality sample
B - Complete (baseline suite) water quality sample
D - Dry
P - Water level, conductivity, temperature, pH
C - Continuous record of water level
D_a - Daily water levels

meter used by tract personnel was giving lower readings during this period; therefore, the conductivity data included in this report have been adjusted by adding 500 micromhos to all tract data, preserving natural variation but

bringing the data up to WWE data range. No appropriate adjustment for temperature and pH data could be identified, however, and values are presented as recorded. These discrepancies are of continuing concern to RBOSC, and every effort is being made to prevent similar problems in future monitoring. Quality control checks have been intensified and will be continued until the problem is satisfactorily resolved.

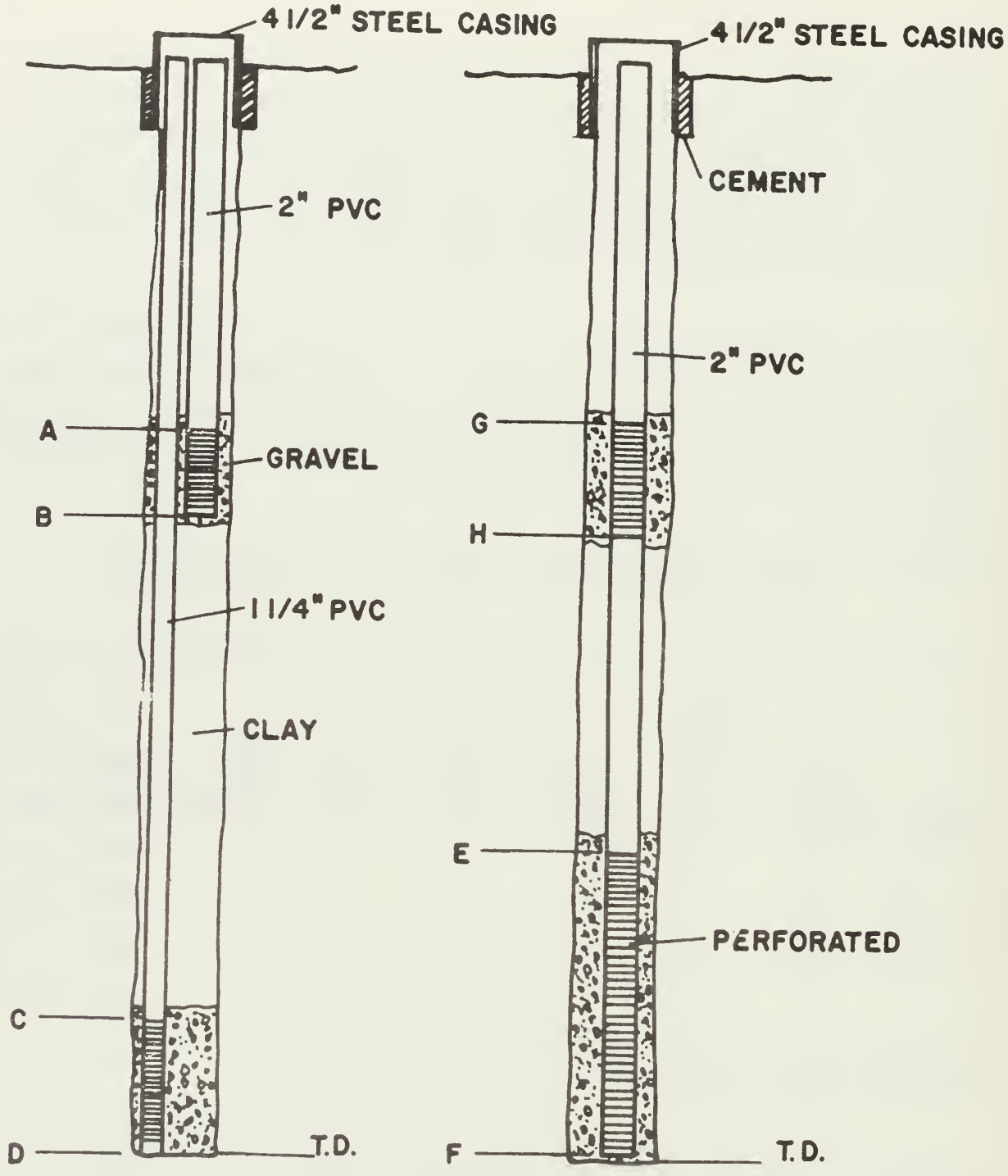
The physical data collected for G-S S7 and G-S S8, which include water level, temperature, conductivity, and pH, do not appear to have varied greatly from the data collected during the baseline period. This was expected since these two monitoring holes are upgradient from any Tract C-a activities.

Table 5-8. Summary of Baseline Data from Alluvial Monitoring Holes 1974-1976 Tract C-a

Hole	Depth (feet)	Mean Static Water Level (feet)	Stand. Dev.	Mean Temp. (°C)	Stand. Dev.	Mean* Cond. (umhos)	Stand.* Dev.
G-S S7	44	21.6	2.5	9.22	2.9	1096	58.0
G-S S8	50	35.7	3.7	9.56	2.9	970	83.3
G-S S11	66	44.0	1.5	10.33	3.0	1796	187.5

*Geometric mean, standard deviation by method of moments.

The water level in G-S S11 in December, January, and early February 1978-79, was approximately the same as the mean depth encountered during the baseline period. However, beginning in late February, water levels began rising and rose to a new minimum depth (Figure 5-16). This rise in the water level corresponds to the increased discharge from the dewatering program in late February. In addition, abnormally high runoff during late April and May may account for a portion of the water level decrease.



SCHEMATIC CROSS SECTION
ALLUVIAL HOLES

Figure 5-6. Diagramatic (Section) Alluvial Monitoring Hole

TABLE 5-9. Well Depths at Various Completion Intervals for Alluvial Wells, Tract C-a

Well No.	T.D.*	LEVEL IN FEET A	B	C	D	E	F	G	H
G-S S6	12	-	-	-	-	3.5	12	-	-
G-S S7	44	-	-	-	-	12.5	44	-	-
G-S S8	50	-	-	-	-	10	50	-	-
G-S S11	66	34	39	50	58	-	-	-	-
G-S S11A	45	27	37	30	40	-	-	-	-
G-S S13	28	-	-	-	-	8	28	-	-
G-S S14	50	-	-	-	-	10	50	-	-
G-S S24	75	-	-	-	-	55	75	15	35
G-S S26	48	31	34	43	48	-	-	-	-
G-S S27	104	40	45	88	93	-	-	-	-
G-S S27A	16	5	15	-	-	-	-	-	-
G-S S28	35	10	15	25	30	-	-	-	-
G-S S29	43	15	20	33	38	-	-	-	-
G-S S29A	44	17	22	34	39	-	-	-	-

*Total Depth

G-S S11 conductivity data from the period December 1978 to late February 1979 compares well with the established baseline values. However, starting in late February, conductivities show a gradual increase over a three-month period to values which are higher than the baseline maximum (Figure 5-17). This same trend is observed in all alluvial holes, including G-S S7 and G-S S8, which are upgradient from site activities. This trend has been reported on a regular (monthly) basis to the AOSO and Colorado Department of Health. Temperature and pH data collected during this reporting period are within baseline maxima and minima.

The water level data for G-S S27 indicate a close association with the discharge from the dewatering program (Figure 5-24). Water levels began rising in late Feburary when the discharges to Corral Gulch were increased. In late March, the discharge point was moved downstream about 1.5 miles to within 200 feet of G-S S27. This move correlates to an almost immediate decline in water level, which continued through the reporting period. Temperature, pH and conductivity data show the same trends as data from G-S S11. The highest DOC value recorded during the reporting period was 11.0 mg/l. The baseline high was 9.15 mg/l.

In summary, the water level, temperature, conductivity and pH of these alluvial monitor holes appear to have responded quite predictably to oil shale operations and, with the exceptions noted above, are within the ranges established during the baseline period. The greatest change in any one of these parameters was the rise in water level in G-S S11 of about 20 feet in response to the dewatering program discharges.

b. Chemical Parameters. Detailed water quality data collected from the alluvial aquifers from 01 December 1978 through 31 May 1979 are included in Appendix 5-2.1 of this report. Statistical summaries of data collected and received from 01 December 1978 through 31 May 1979 from individual alluvial wells are presented in Appendix 5-2.2. A statistical summary of all alluvial wells as a single group is presented in Table 5-10. Additional statistical summaries of off-tract and on-tract wells are included in Appendix 5-2.3.

Table 5-11 compares the data collected during the baseline period for each of the four holes studied (G-S S7, G-S S8, G-S S11, and G-S S24) with the data collected from the same holes during the 1978-1979 monitoring period. In order to determine if stated null hypotheses are reasonable, special statistical tests (F & t) were performed using the six-month data set. These tests revealed that several constituents were significantly different from baseline, causing us to reject the null hypothesis. Those parameters which failed the F and/or t-tests at the 95% confidence level and for the degrees of freedom shown on Table 5-11, are indicated by a "+." The parameters which failed the F-test were retested with a t'-test because certain

Table 5-10. Summary Statistics of Water Quality Data Collected From Alluvial Aquifer Holes (G-S S7, G-S S8, G-S S11, G-S S11A, G-S S24, G-S S27, G-S S28, G-S S28A, G-S S29, G-S S29A) During the Period December 1978-May 1979, Tract C-a.

COREHOLE WATER STATISTICAL ANALYSIS
REPORT TYPE :A AQUIFER :A WET SAMPLES DATE 07/11/79

PARAMETER	DESCRIPTION	NUMBER		MAXIMUM	MINIMUM	MEAN	STD. DEV.	95% C.L.(U-L)		25%	50%	75%	90%	95%
&01106	ALUMIN	4		400.00<	100.00	141.42	2.00	370.12	54.04	88.58	141.42	225.79	343.90	442.29
&71846	AMMONI	4		0.70	0.28	0.43	1.46	0.72	0.25	0.33	0.43	0.55	0.69	0.79
&01000	ARSENI	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00440	BICARB	18		750.00	384.00	542.70	1.31	621.26	474.07	451.36	542.70	652.52	770.14	850.37
&01025	CADMIU	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00915	CALCIU	31		200.00	39.00	106.76	1.26	106.76	106.76	91.55	106.76	124.49	142.93	155.25
&00445	CARBON	14	<	0.10<	0.10<	0.10	1.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10
00940	CHLORI	31		200.00	10.00	22.61	1.70	22.61	22.61	15.83	22.61	32.29	44.50	53.90
&01030	CHROMI	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00950	FLUORI	31		0.70	0.17	0.33	1.32	0.33	0.33	0.28	0.33	0.40	0.48	0.53
&01046	IRON	4		380.00<	50.00	169.75	2.38	564.50	51.05	94.63	169.75	304.50	515.00	705.16
&01049	LEAD	4		20.00	10.00	11.89	1.41	19.24	7.35	9.41	11.89	15.03	18.54	21.03
00925	MAGNES	31		240.00	29.00	76.85	1.82	76.85	76.85	51.27	76.85	115.20	165.77	206.09
&71890	MERCUR	4	<	1.00<	1.00<	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
71851	NITRAT	11		16.00	1.30	5.14	2.99	10.63	2.48	2.45	5.14	10.77	20.95	31.19
&70507	PHOSPH	4	<	0.10<	0.10<	0.10	1.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10
00935	POTASS	14		4.00	1.30	2.80	1.34	3.32	2.37	2.30	2.80	3.42	4.09	4.55
&01145	SELENI	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00955	SIL DI	31		38.00	2.90	21.00	1.20	21.00	21.00	18.55	21.00	23.78	26.59	28.42
00930	SODIUM	31		800.00	61.00	174.68	1.67	174.68	174.68	123.59	174.68	246.89	337.00	405.92
00945	SULFAT	31		1600.00	150.00	464.44	1.87	464.44	464.44	303.86	464.44	709.88	1039.64	1306.10
&00746	SULFID	4	<	0.20<	0.10<	0.17	1.41	0.27	0.10	0.13	0.17	0.21	0.26	0.30
&01090	ZINC	4		700.00	500.00	569.24	1.18	713.22	454.33	510.12	569.24	635.21	701.04	743.62
&01503	GROSS	4		12.00	2.50	6.91	2.05	18.76	2.54	4.25	6.91	11.23	17.38	22.57
# 00400	PH	21		8.00	7.00	7.51	0.34	7.66	7.35	7.28	7.51	7.74	7.94	8.07
00095	CONDUC	18		2800.00	1000.00	1620.06	1.34	1873.06	1401.24	1329.33	1620.06	1974.38	2358.72	2623.43
&00540	DIS SO	4		1730.00	840.00	1214.79	1.35	1833.57	804.84	994.38	1214.79	1484.06	1776.82	1978.80
00410	ALKALI	31		840.00	255.00	486.67	1.27	486.67	486.67	414.83	486.67	570.94	659.12	718.23
&00720	CYANID	4	<	0.01<	0.01<	0.01	1.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
&01020	BORON	8		300.00	100.00	148.77	1.56	213.83	103.51	110.18	148.77	200.89	263.18	309.31
&00681	DOC	4		12.00	4.30	6.82	1.68	13.97	3.33	4.81	6.82	9.66	13.22	15.95
&00613	NITRIT	3	<	0.01<	0.01<	0.01	1.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
&71870	BROMID	4	<	0.10<	0.10<	0.10	1.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10
&00340	C.O.D.	4		15.00	5.00	7.83	1.72	16.63	3.68	5.42	7.83	11.29	15.70	19.12
&32730	PHENOL	4	<	1.00<	1.00<	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
&01080	STRONT	4		3500.00	1200.00	1996.11	1.56	3689.45	1079.97	1480.64	1996.11	2691.05	3520.37	4133.87

Table 5-10. (Continued)

COREHOLE WATER STATISTICAL ANALYSIS

REPORT TYPE :A AQUIFER :A SPEC SAMPLES DATE 07/11/79

PARAMETER DESCRIPTION	NUMBER	MAXIMUN	MINIMUN	MEAN	STD. DEV.	95% C.L.(U-L)		25%	50%	75%	90%	95%
# 00011 TEMPER	31	51.80	40.10	47.48	3.79	47.48	47.48	44.92	47.48	50.04	52.34	53.71
# 00003 DEPTH	25	47.48	6.19	28.54	13.82	34.24	22.85	19.21	28.54	37.87	46.26	51.28

END OF AQUIFER A SAMPLES REPORTING PERIOD IS 120178. THRU 53179.

---

* -- ESTIMATE USING METHOD OF MOMENTS
# -- NO LOG TRANSFORM
& -- BESTFIT IS ONLY AN ESTIMATE

Table 5-11. Summary of Statistical Tests for Alluvial Holes G-S S7, G-S S-8 G-S S11, and G-S S24, Tract C-a.

Hole	G-S S7			G-S S8			G-S S11			G-S S24		
Statistical Test	t	F	t'	t	F	t'	t	F	t'	t	F	t'
Parameter												
Alkalinity					+	p	+	+	p		+	p
Calcium					+	p					+	p
Carbonate												
Chloride	+											
Fluoride		+	p				+		p	+		
Magnesium											+	p
Nitrate	+	+	p									
Potasium											+	
Silica		+	p	+	+	p	+	+	f	+	+	f
Sodium	+				+	p	+	+	p	+		
Sulfate	+	+	p	+	+	p		+	p		+	p
pH	+	+	p	+			+			+	p	+
Cond	+	+	p									
Temp					+	p						
Depth	+			+			+	+	p	+	p	

\+ Failed statistical test as indicated

p Passed t' test

f Failed t' test

DEGREES OF FREEDOM

t-test $n_1 + n_2 - 2$

F-test $n_1 - 1, n_2 - 1$

t'-test $$\frac{(S_1^2/n_1 + S_2^2/n_2)^2}{\frac{(S_1^2/n_1)^2}{(n_1-1)} + \frac{(S_2^2/n_2)^2}{(n_2-1)}}$$

assumptions used in the t-test would be invalid after an F-test failure. It is assumed in a t-test that all samples are from the same population whereas an F-test failure suggests the opposite. The equation used for the t'-test is given in Appendix 5-2.6. However, alluvial well data collected during the reporting period are for only a portion of the year, complicating and possibly introducing bias in any comparison with baseline data.

Control Stations G-S S7 and G-S S8, upgradient from tract activities, are not likely to have been affected by development. Therefore, the significant differences between baseline values and MDP values measured at these stations probably represent natural variations. Except for magnesium and potassium in G-S S24, all other parameter failures in G-S S11 and G-S S24 are matched by similar F-test failures in the control stations G-S S7 and G-S S8. Natural variation and possibly the lack of seasonal compatibility may explain the difference from baseline data.

Lack of evidence to support the rejection of the null hypothesis on the basis of development-related impacts in concert with apparent natural fluctuations (G-S S7 and G-S S8) demonstrates that this mechanism alone cannot be used to define perturbations. The review of the data will continue, and data will be reevaluated at the end of the reporting period in the year-end report.

The Trilinear diagram (Figure 5-7) has the same distribution as the trilinear diagram of the combined alluvial aquifer as presented in the Final Environmental Baseline Report, except for one outlyer. This outlyer is a single analysis for hole G-S S8 and shows higher proportions of sodium plus potassium than calcium and magnesium. This point may represent natural variation in alluvial water quality since this hole is upstream of any tract activity.

B. Deep (Upper and Lower) Oil Shale Aquifers

1. Objectives

During the MDP, deep oil shale aquifers (upper and lower) are monitored to

Figure 5-7. Trilinear Diagram of Combined (G-S S7, G-S S8, G-S S11, G-S S11A, G-S S24, G-S S27, G-S S28, G-S S28A, G-S S29, and G-S S29A) Alluvial Aquifer Analyses for December 1978 to May 1979.

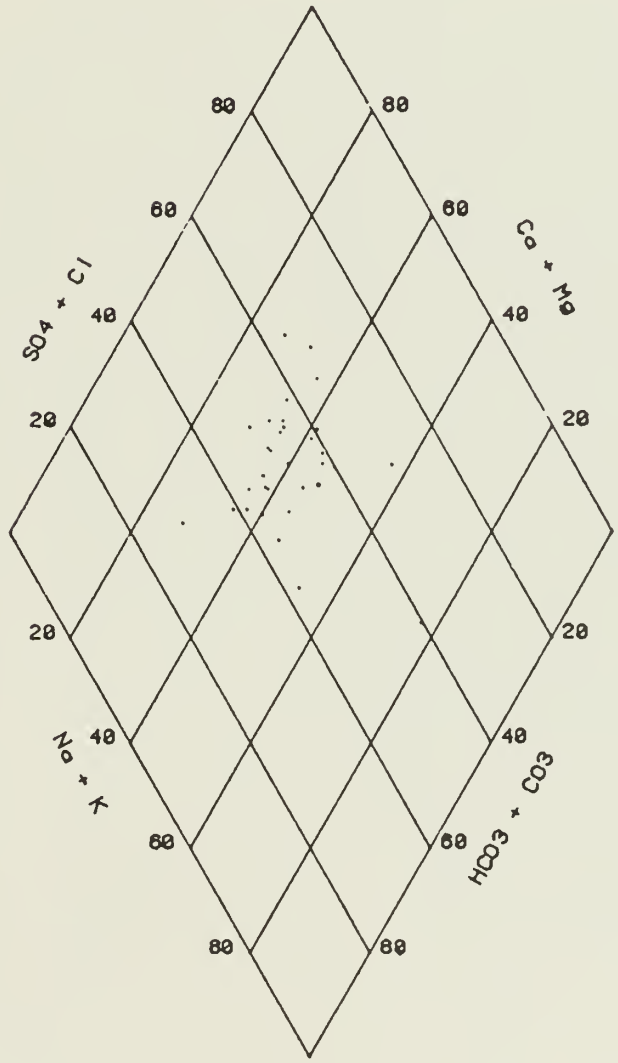


Figure 5-8. G-S S7 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

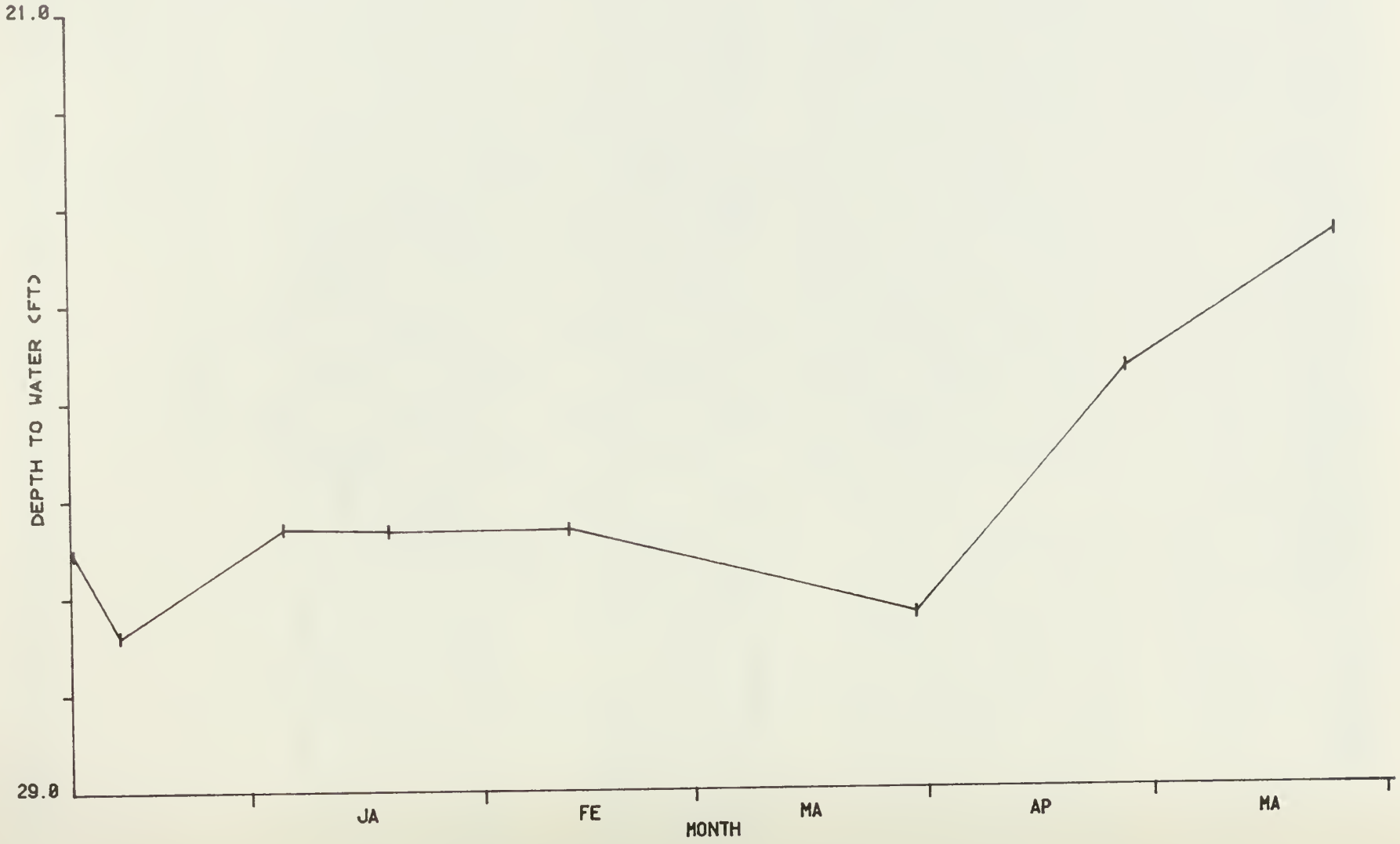


Figure 5-9. G-S S7 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

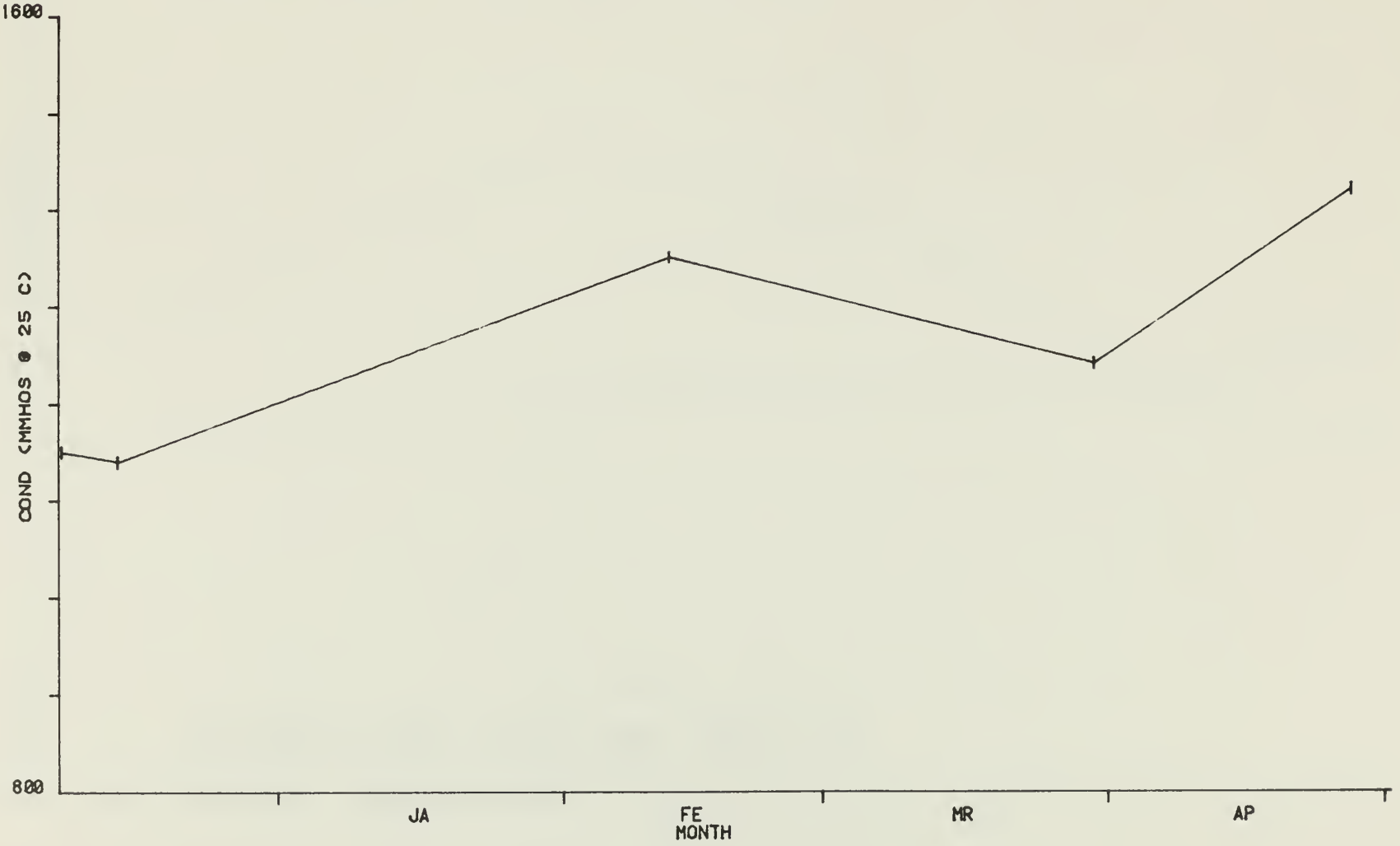


Figure 5-10. G-S S7 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

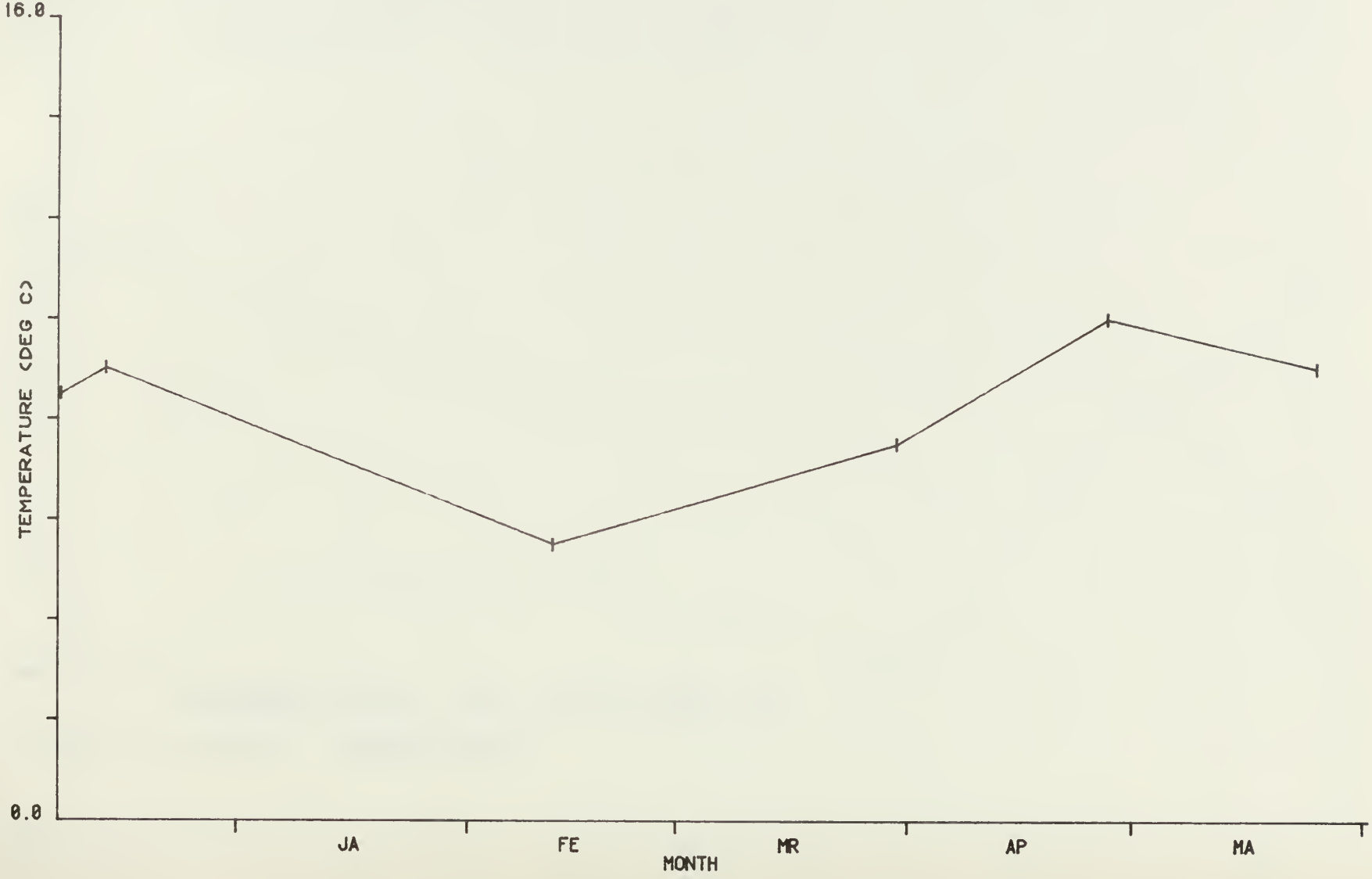


Figure 5-11. G-S S7 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

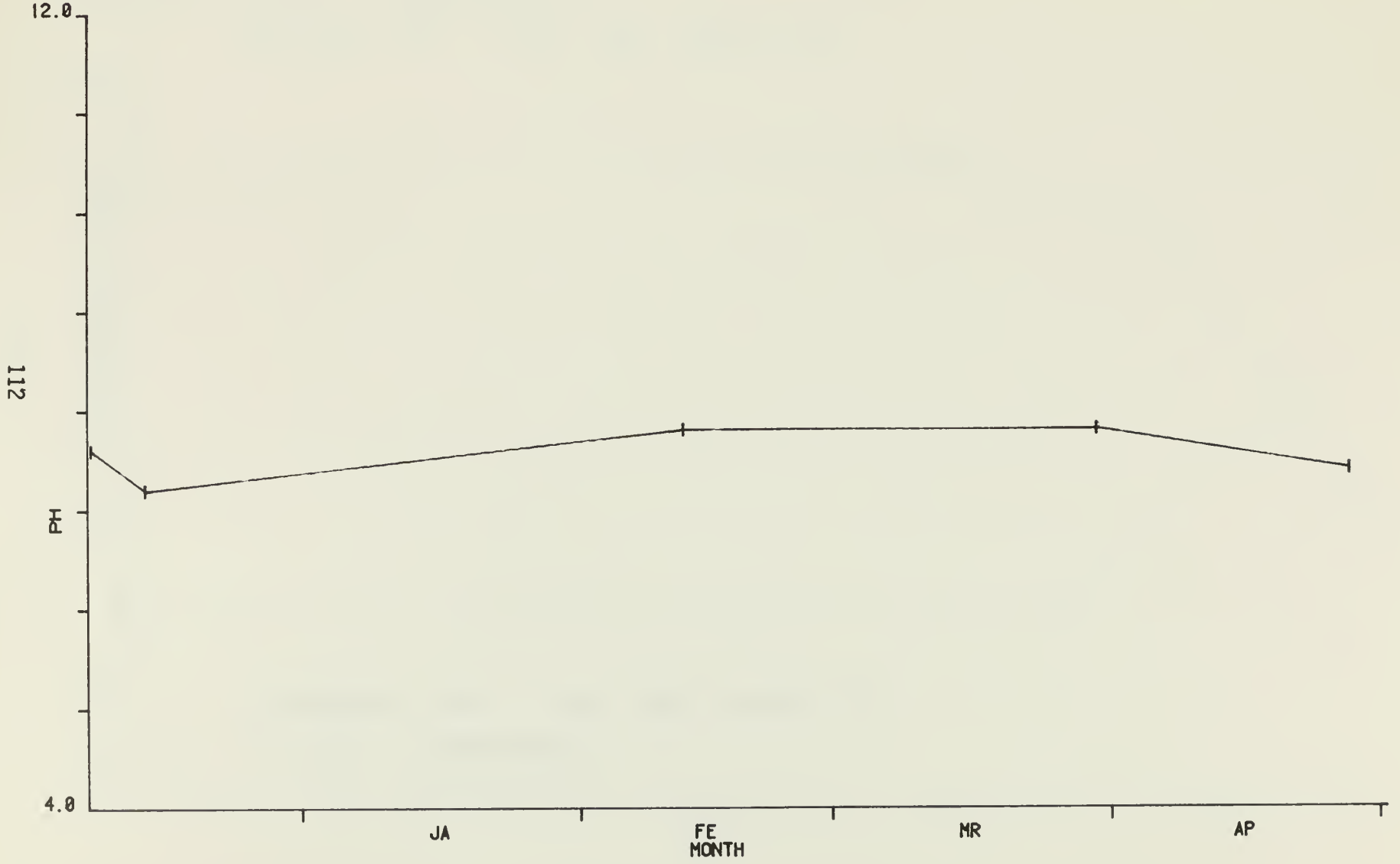


Figure 5-12. G-S S8 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

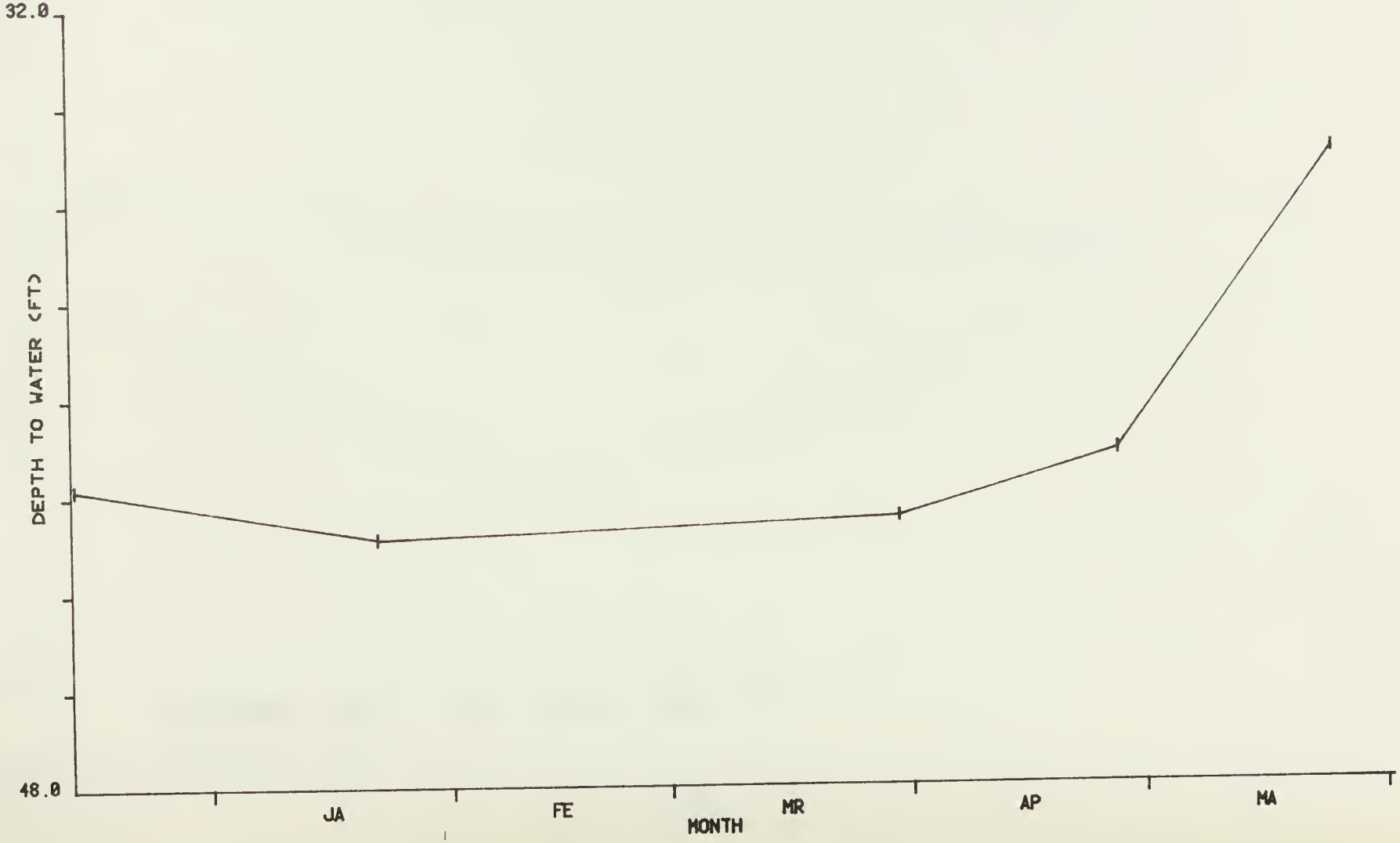


Figure 5-13. G-S S8 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

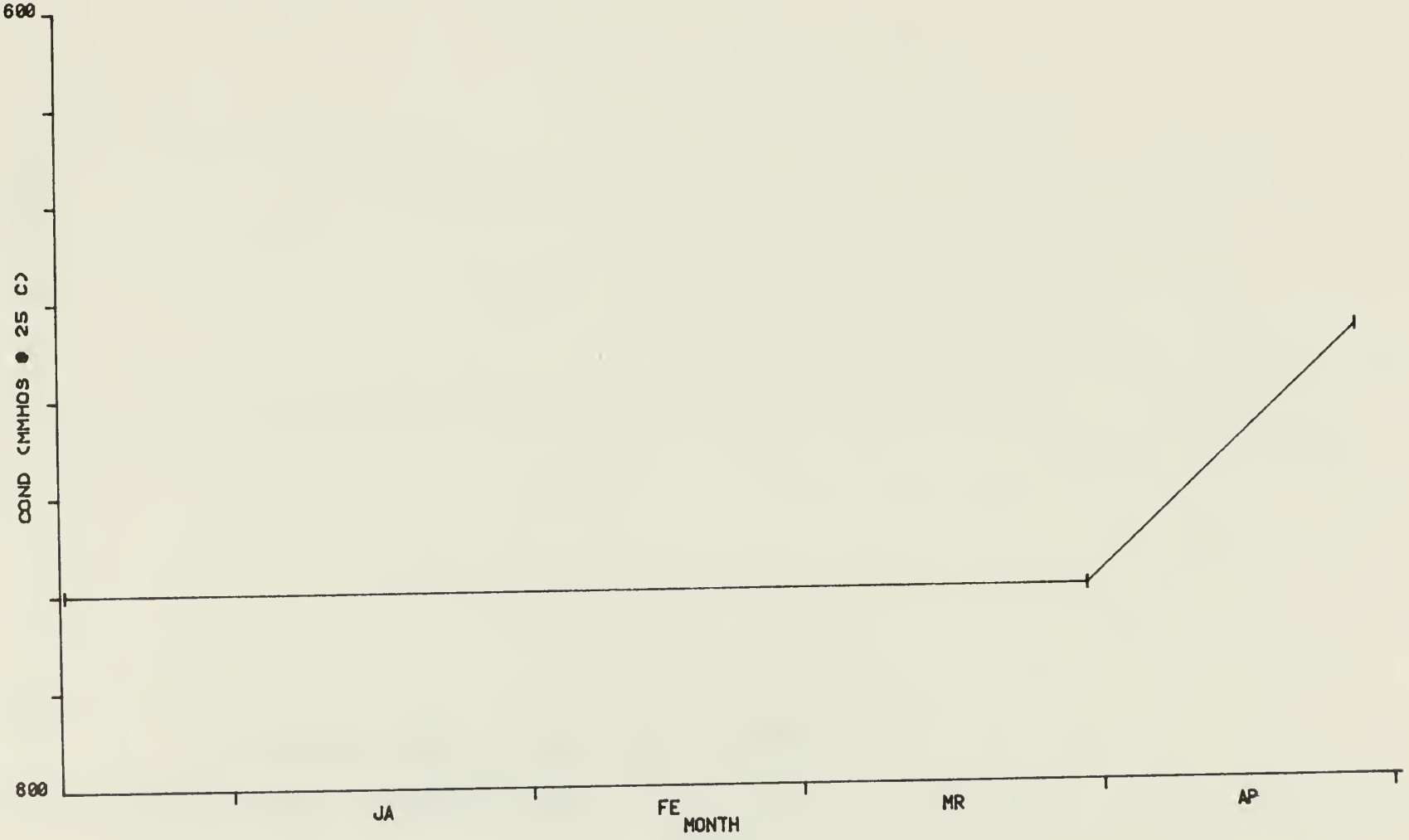


Figure 5-14. G-S S8 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

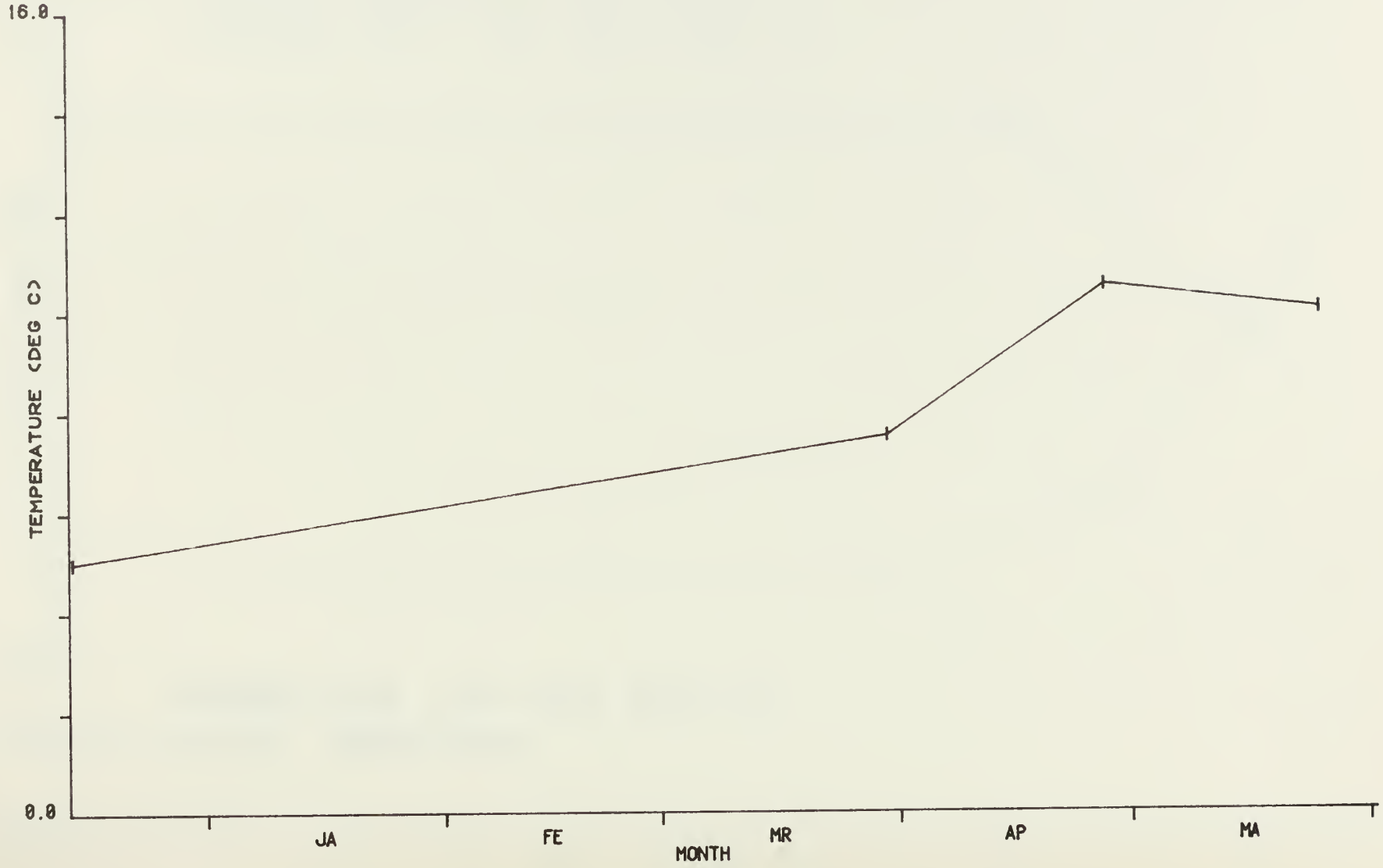


Figure 5-15. GS-S8 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

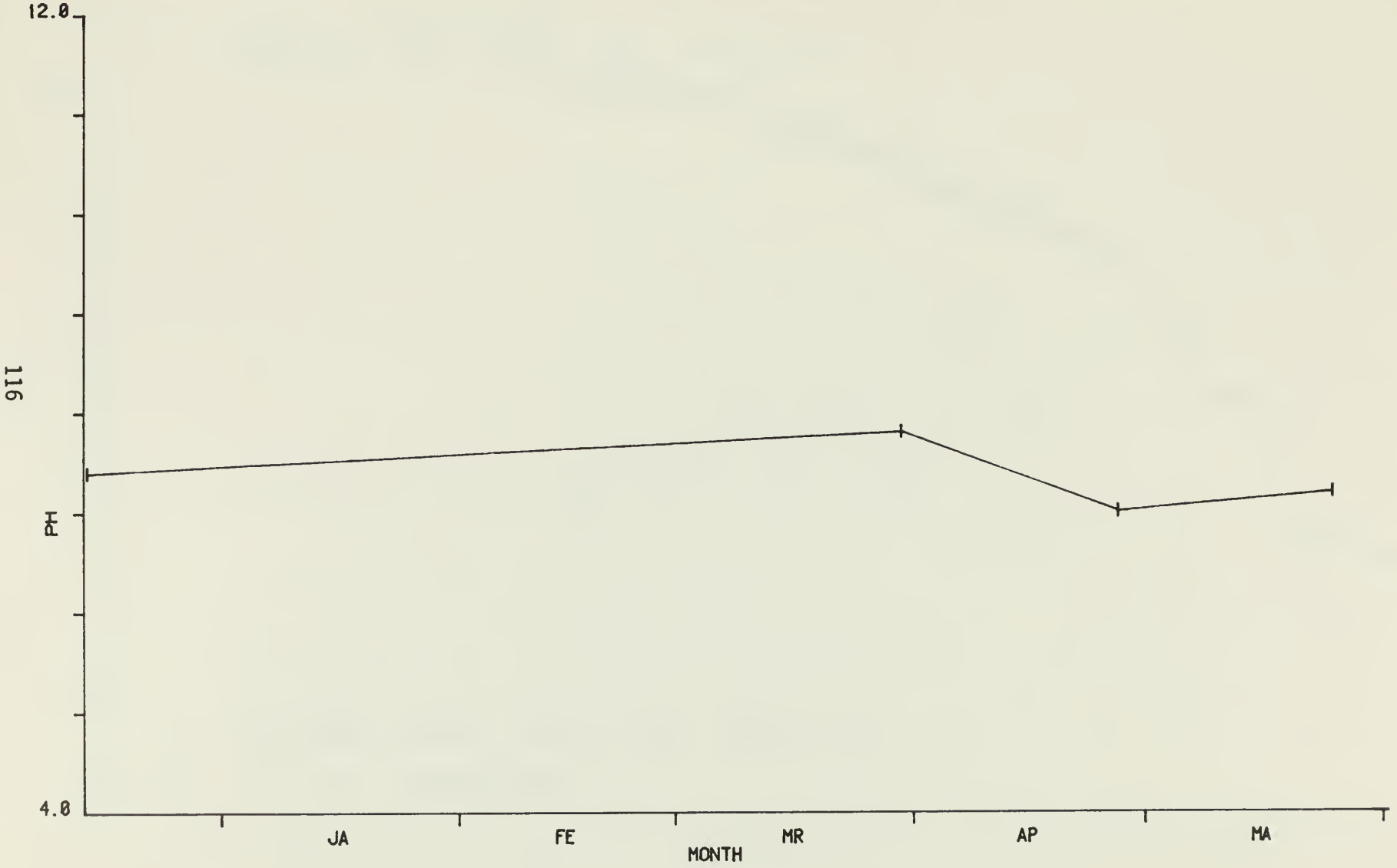


Figure 5-16. G-S S11 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

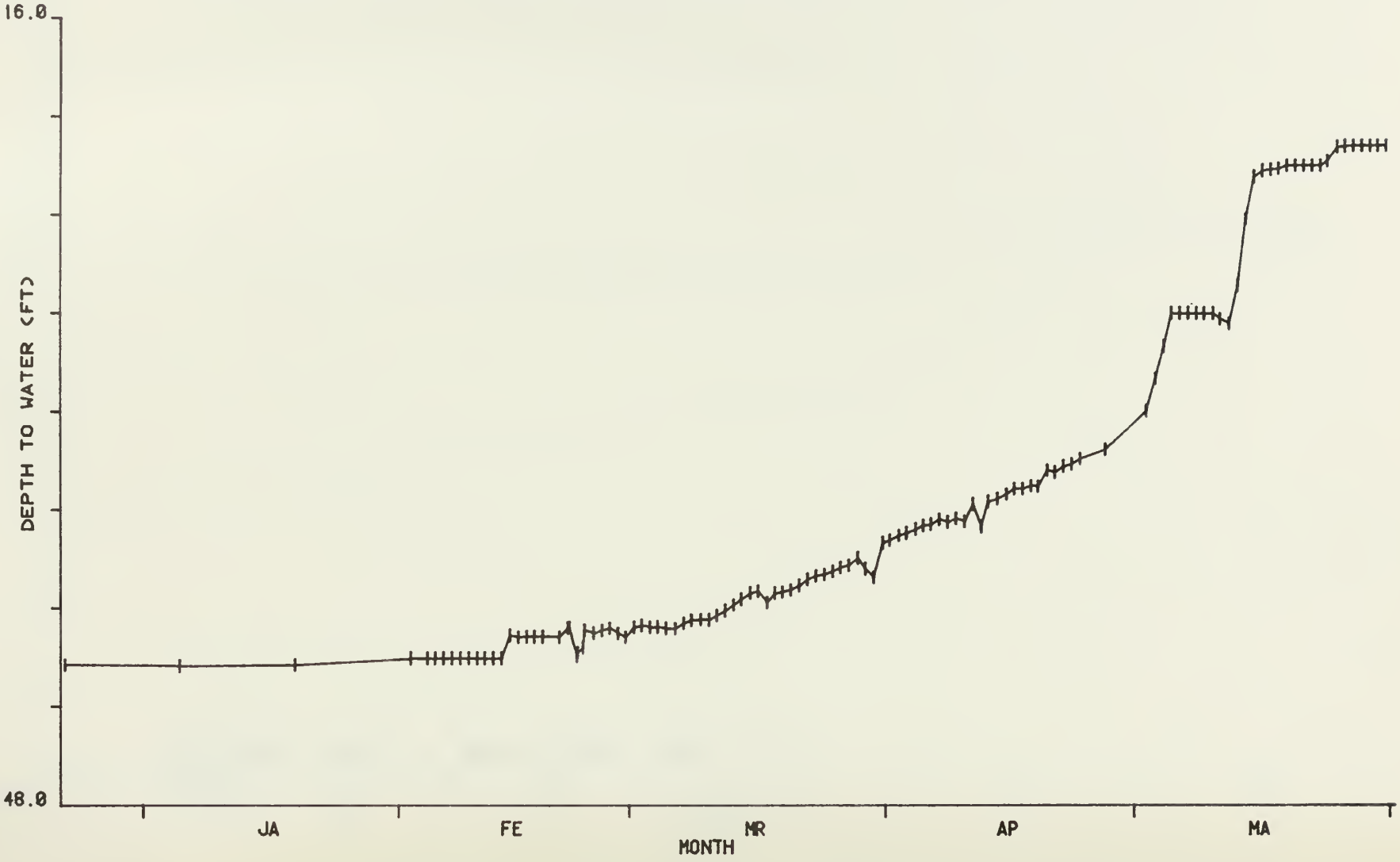


Figure 5-17. G-S S11 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

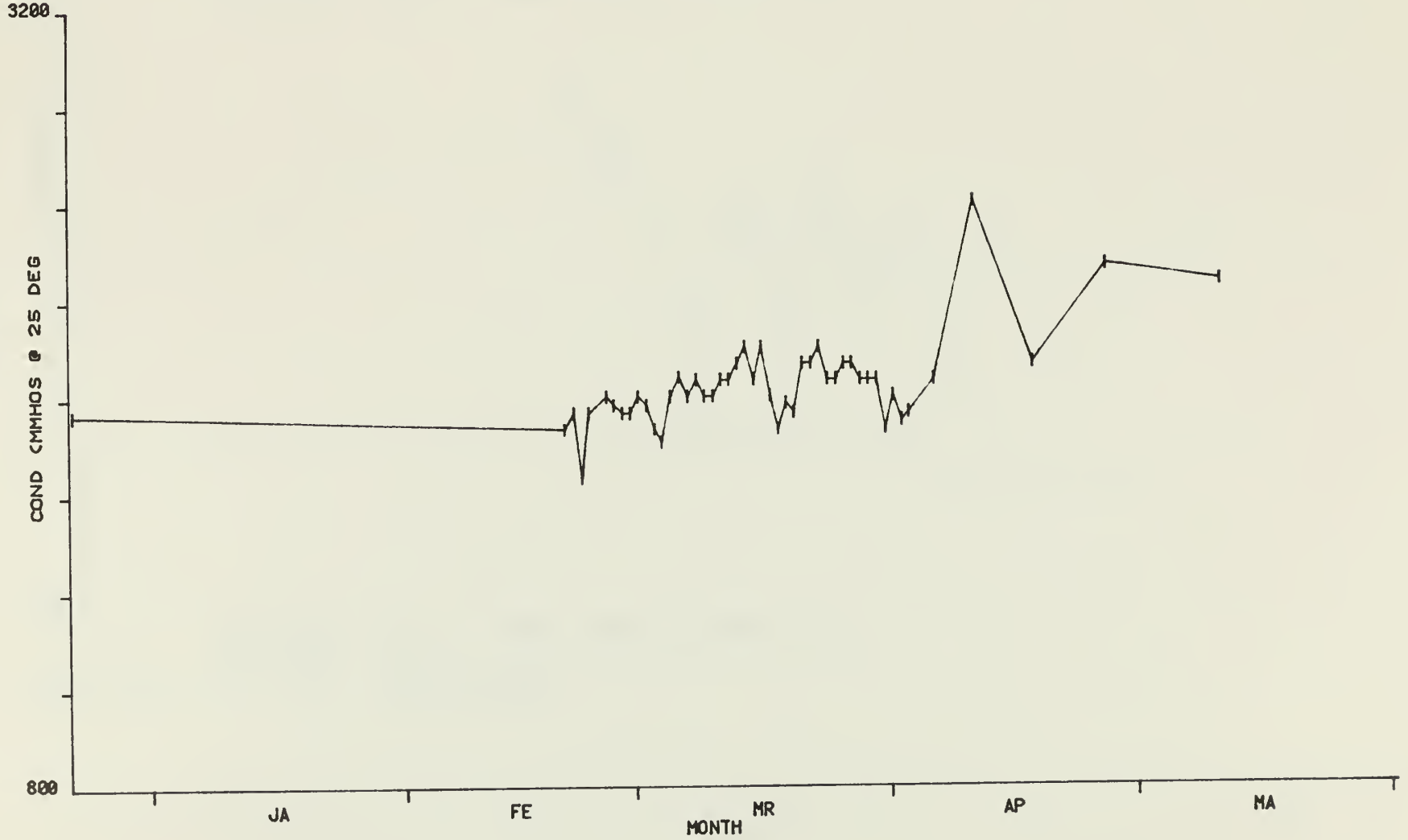


Figure 5-18. G-S S11 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

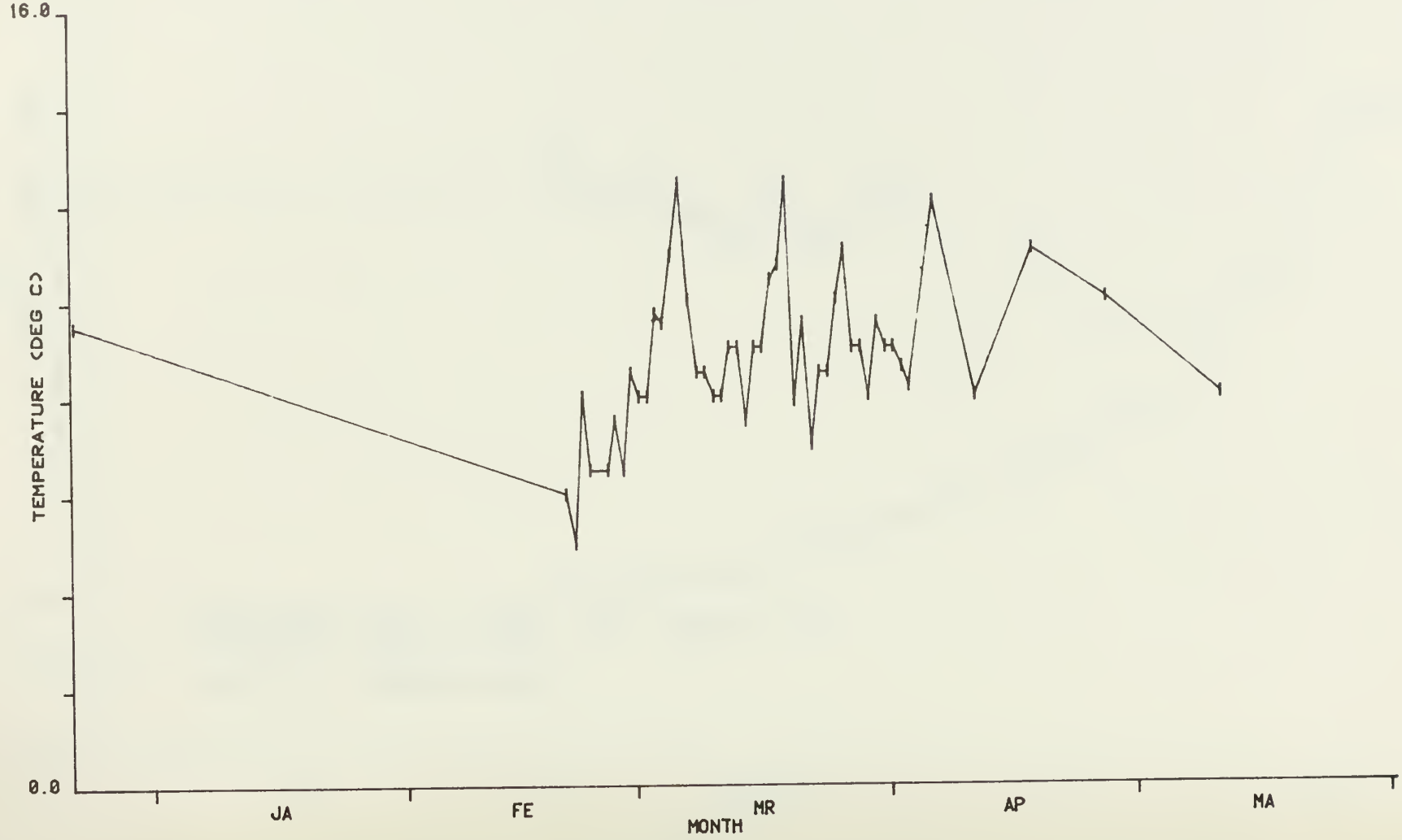


Figure 5-19. G-S S11 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

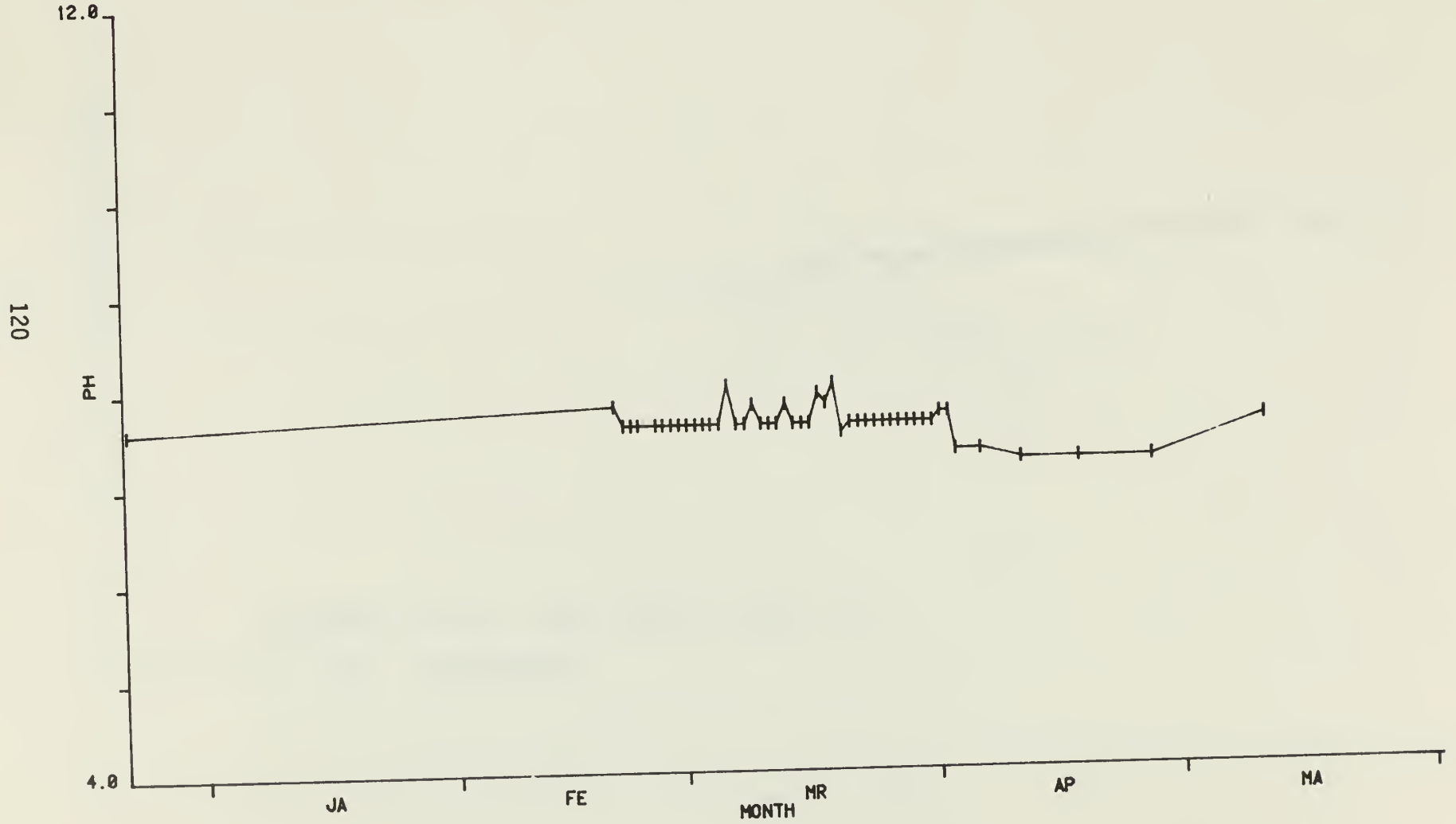


Figure 5-20. G-S S24 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

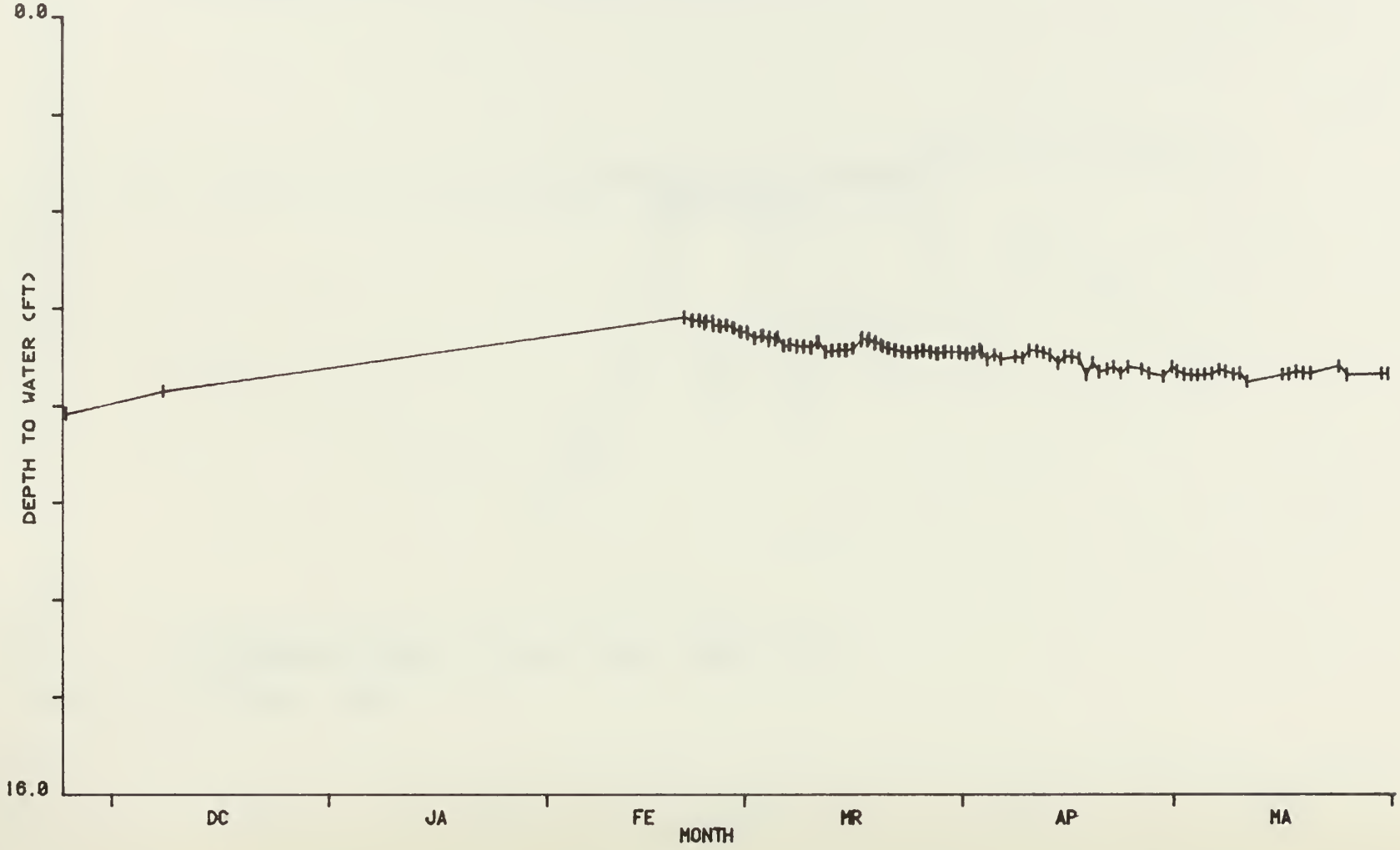


Figure 5-21. G-S S24 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

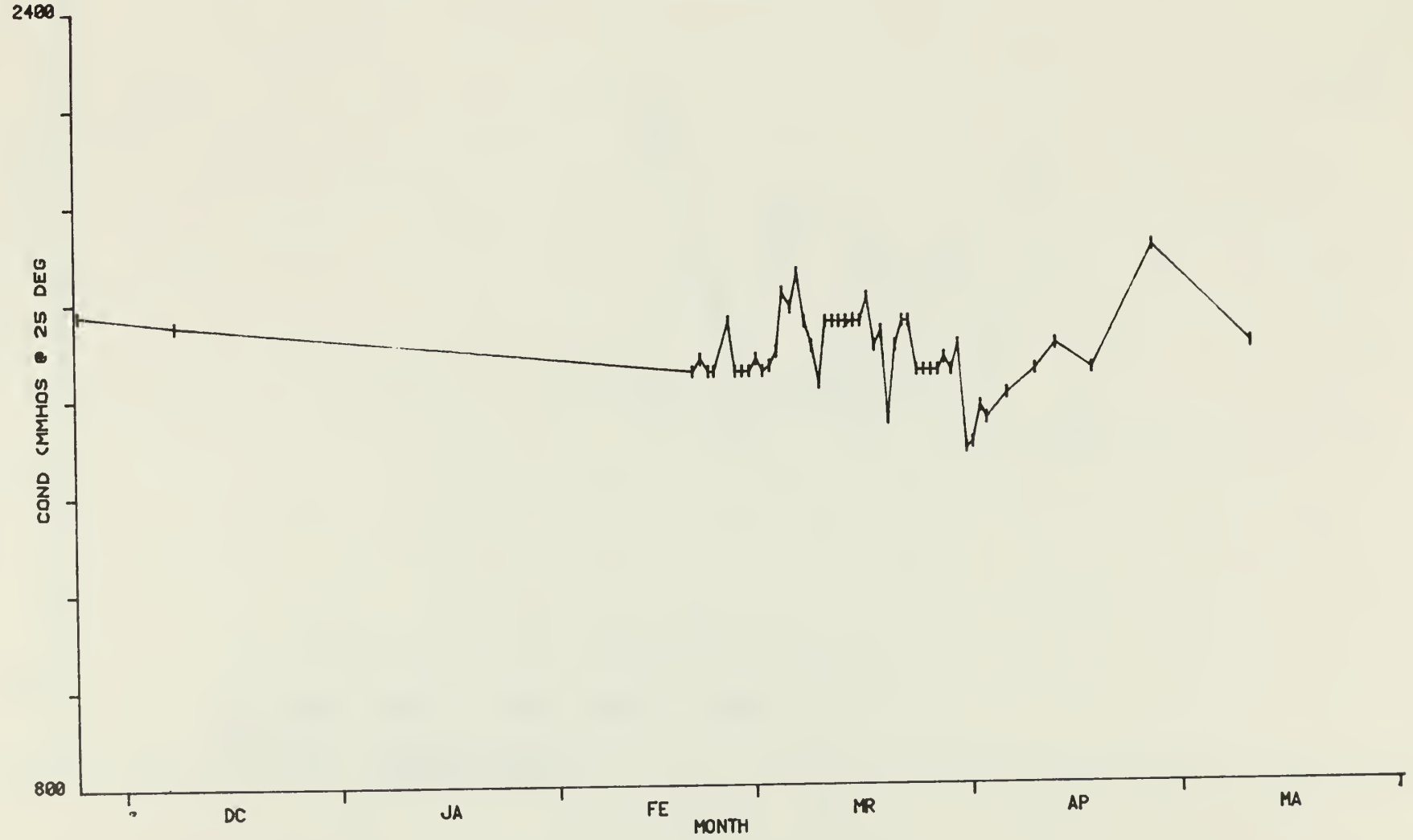


Figure 5-22. G-S S24 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

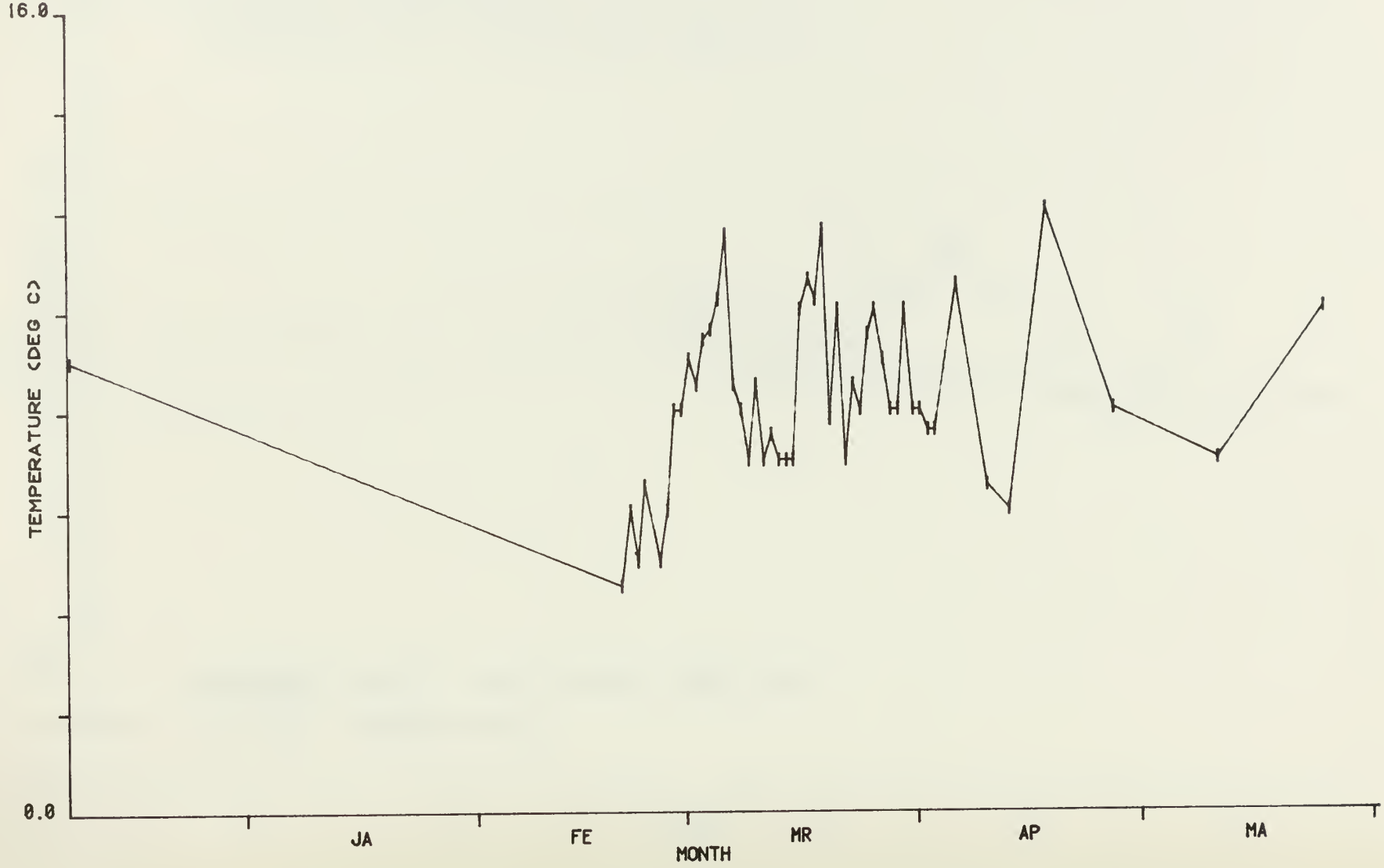


Figure 5-23. G-S S24 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

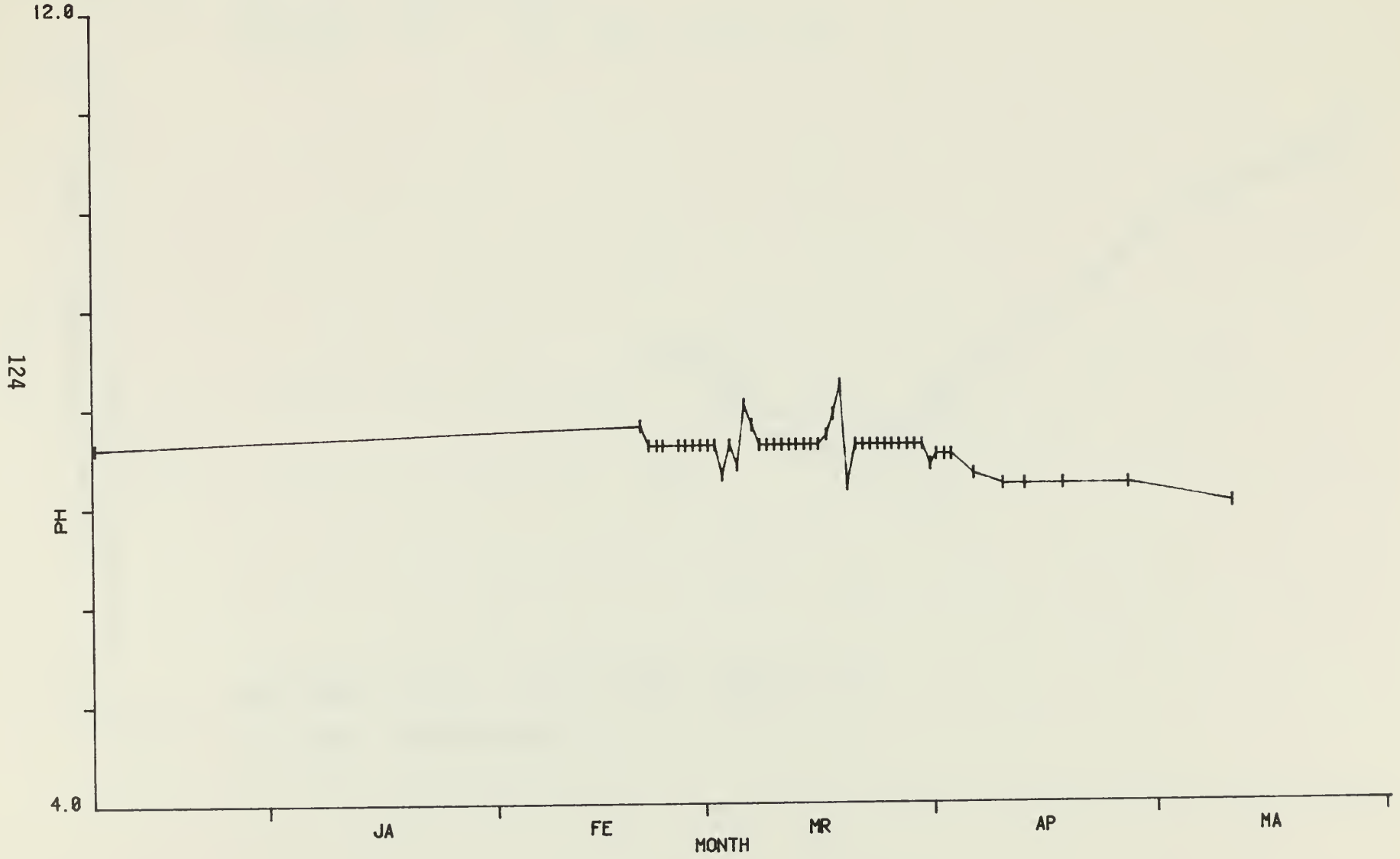


Figure 5-24. G-S S27 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

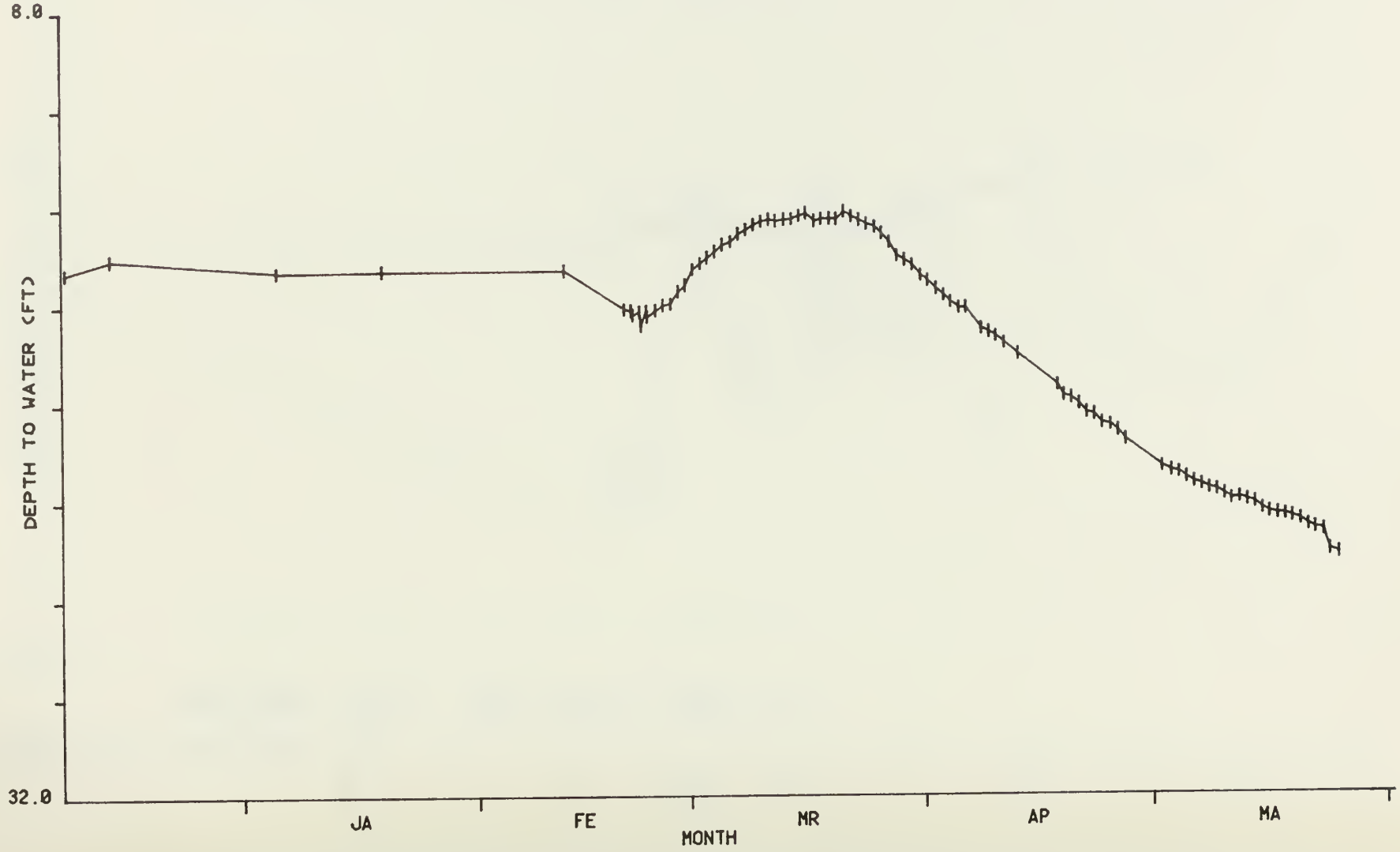


Figure 5-25. G-S S27 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

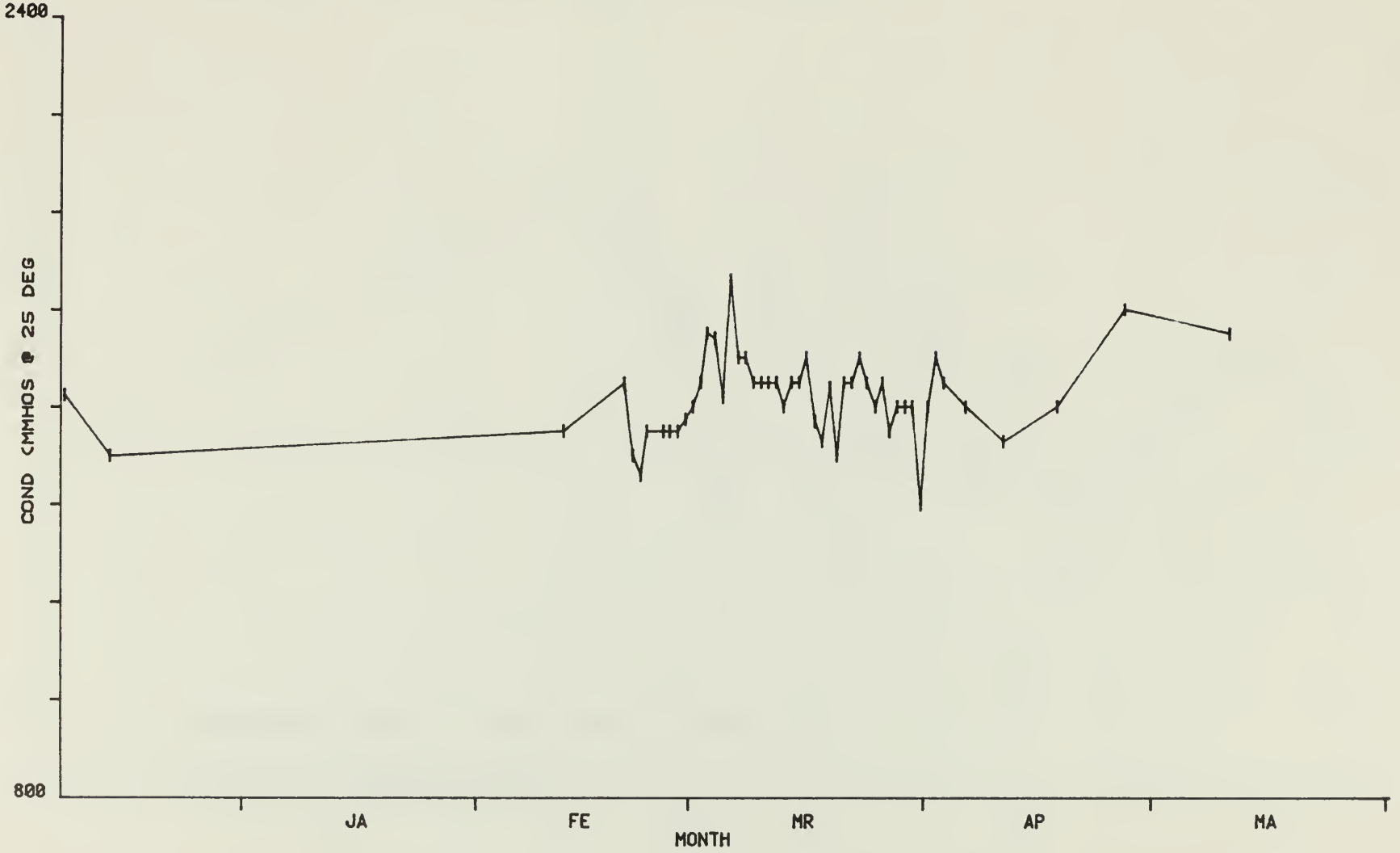


Figure 5-26. G-S S27 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

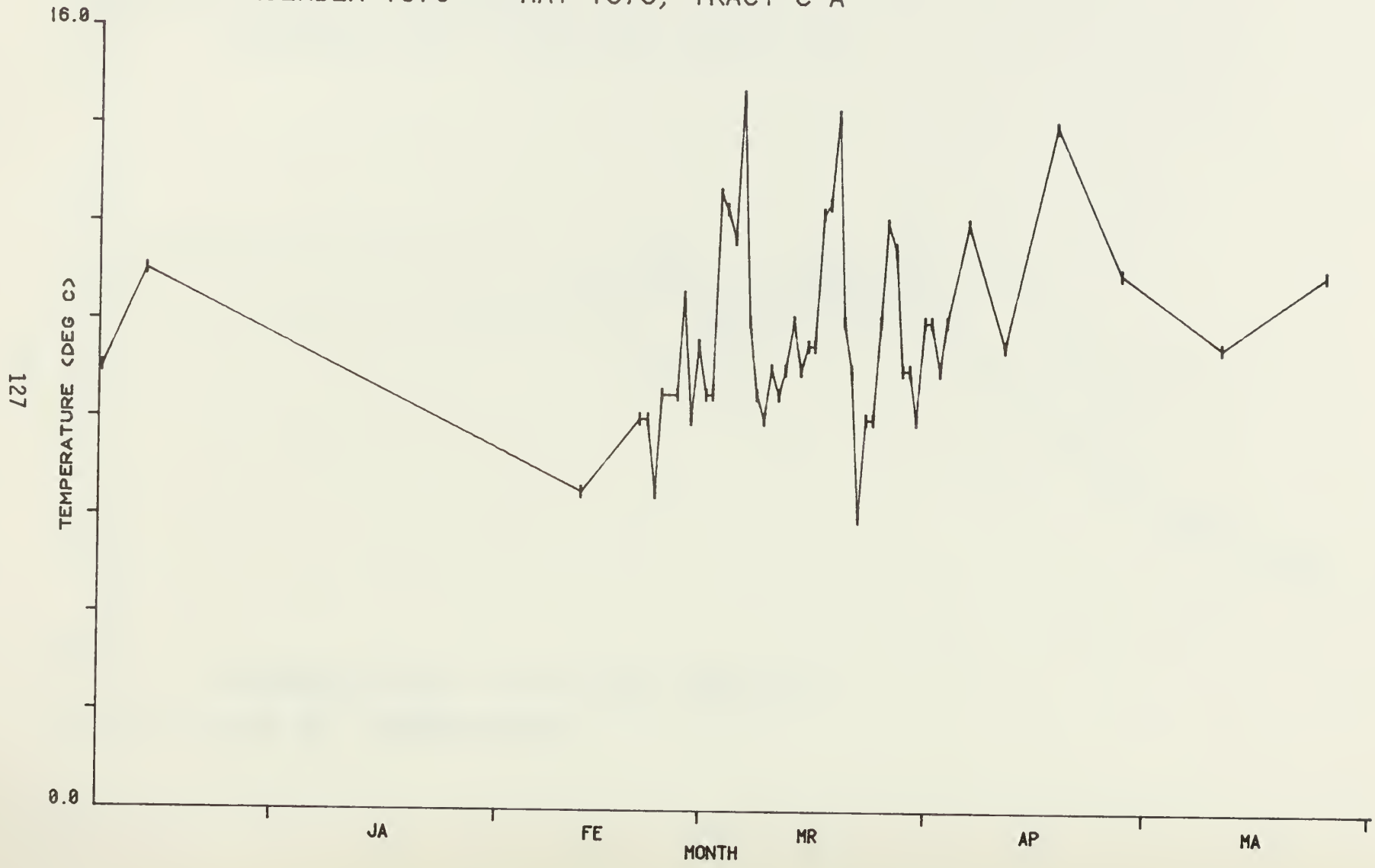
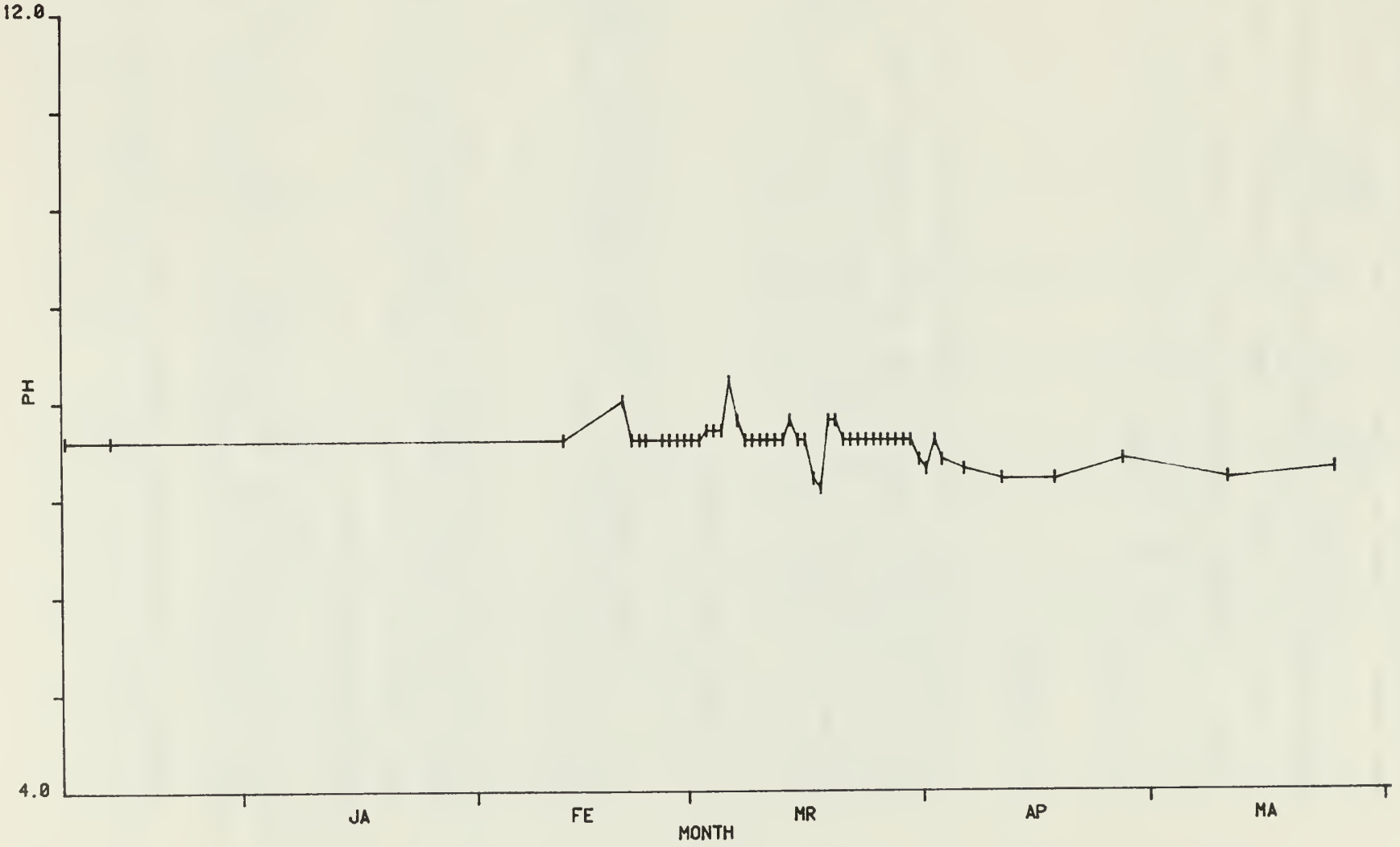


Figure 5-27. G-S S27 PH
DECEMBER 1978 — MAY 1979, TRACT C-A



collect and analyze data on current water levels and water quality and compare those to data on water levels and water quality existing prior to mining and development operations. The objective of this process is to detect changes in the character of the aquifer, determine if the changes are significant, and analyze the changes to determine if they are caused by mining or development operations, such as dewatering and reinjection. In addition, it is the objective of this monitoring program to determine if lease and permit requirements, as well as applicable laws and regulations, are being met.

2. Methods

The methods followed for collection of these data were described in the RBOSC MDP Monitoring Report 2, and are not repeated herein. The locations of the monitoring holes are found on Map 1 (Map Pocket). Revised completion diagrams for all monitoring holes included in the current program have been presented in Appendix 5-2.6 of the Year-End Report (1977-1978).

3. Results and Discussion

a. Physical Parameters - Table 5-12 shows the monitoring schedule of the deep oil shale aquifer (upper and lower) monitoring holes for environmental purposes.

The water level in AM-3 showed very little change during the reporting period (Figure 5-29) and was close to the baseline mean of 36.88 feet. The upper aquifer in the vicinity of AM-3 is not influenced by dewatering or reinjection activities.

The water level in G-S M1 during December, January, and most of February of this reporting period is a continuation of the high levels seen in August through November of 1978 (Figure 5-33). These high water levels are in response to the reinjection program. When reinjection was suspended in late

Table 5-12. Upper and Lower Aquifer Monitoring Summary, Tract C-a

	1978	1979				
Hole #	Dec	Jan	Feb	Mar	Apr	May
AM-3	Da	Da	Da,P	Da,P	Da,P	C,P
		(L)	(L)	(L)	(L)	(L)
GS M1	X	X	Da,P	Da,P	Da,P	C,P
		(L)	(L)	(L)	(L)	(L)
G-S M2	X	X	Da,P	Da,P	Da,P	C,P
		(B)	(L)	(L)	(L)	(L)
G-S M3		X	P	Da,P	Da,P	C,P
		(B)	(L)	(L)	(L)	(L)
G-S M4	X	X	X	Da,P	Da,P	C,P
		(B)	(L)	(L)	(L)	(L)
G-S 15 Upper	X	X	Da,P	Da,P	Da,P	C,P
		(B)	(L)	(L)	(L)	(L)
G-S 15 Lower	X	X	Da,P	Da,P	Da,P	C,P
		(B)	(L)	(L)	(L)	

Da - Daily water levels
P - Water level, conductivity, temperature, pH
C - Continuous record of water levels
X - At least one water level
L - Limited
B - Baseline water quality sample

February 1979, water levels dropped, with very little lag time, to a low of 627 feet in late May (Figure 5-33).

Water levels in G-S M2 varied between 217 and 219 feet during the reporting period (Figure 5-37). This variation is nearly identical to that seen during the last reporting period, suggesting the upper aquifer in the vicinity of G-S M2 is not affected by either the dewatering or reinjection programs.

G-S M3 water levels showed very little fluctuation during the reporting period (Figures 5-41). The water levels, however, were higher than the reported baseline minimum of 18.57 feet. The high water levels may be due to

long-term reinjection into the upper aquifer and a time-lag since suspension of reinjection.

The water level in G-S M4 was stable at about 520 feet during the period of December 1978 to February 1979 (Figure 5-45). There was a water level drop between 05 February and 19 February which may have been caused by a reduction in the reinjection rate seen in Figure 5-4 between January and February. The injection well shutdown on 23 February explains the continued decline in water levels after that date.

The water level in G-S 15 Upper showed a steady decline throughout the reporting period, starting at a previous low of 287.95 feet in December 1978 to a new low of 301.18 feet in May 1979 (Figure 5-49). As was concluded in the last Year-End Report, G-S 15 Upper does not respond to reinjection.

G-S 15 Lower water levels fluctuated between 371 and 374 feet during the reporting period, within the minimum and maximum baseline levels (Figure 5-53). The observation of only minor fluctuations reflect the lack of activity with the lower aquifer during the reporting period.

In summary, upper aquifer holes AM-3, G-S M2, G-S M3, and G-S 15 Lower show no effects of dewatering or reinjection. Holes G-S M1 and G-S M4 show definite correlation with the dewatering and reinjection programs, and G-S 15 Upper is affected by dewatering, but apparently not reinjection.

b. Chemical Parameters - Detailed water quality data collected from the deep aquifers during the reporting period, 01 December 1978 to 31 May 1979, are presented in Appendix 5-2.4. Summary statistics of individual holes are reported in Appendix 5-2.5. A statistical summary of the upper aquifer is presented in Table 5-13.

The parameters which failed the t- and F-tests are listed in Table 5-14. All t-tests, where the parameter also failed the F-test, have been checked by the t'-test. All t-tests were substantiated except magnesium in G-3 M3 and alkalinity in G-S M2 which showed the t-test to be incorrect.

Table 5-13. Summary Statistics of Water Quality Data Collected from Upper Aquifer Holes (AM-3, G-S M1, G-S M2, G-S M3, G-S M4, G-S 15 Upper) During the Period December 1978 - May 1979, Tract C-a.

COREHOLE WATER STATISTICAL ANALYSIS

REPORT TYPE :A AQUIFER :U WET SAMPLES DATE 07/12/79

PARAMETER	DESCRIPTION	NUMBER		MAXIMUM	MINIMUM	MEAN	STD. DEV.	95% C.L.(U-L)		25%	50%	75%	90%	95%
&01106	ALUMIN	4		550.00<	100.00	153.14	2.35	499.92	46.91	86.14	153.14	272.25	456.73	622.36
&71846	AMMONI	1	<	0.14<	0.14<	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
&01000	ARSENI	4	<	50.00<	10.00<	33.44	2.24	102.17	10.94	19.42	33.44	57.56	93.81	125.64
00440	BICARB	15		700.00	220.00	466.69	1.40	561.05	368.19	372.31	466.69	584.98	716.75	809.34
&01025	CADMIU	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00915	CALCIU	30		133.00	4.90	39.44	2.08	51.85	30.01	24.04	39.44	64.71	101.00	131.82
00445	CARBON	16		190.00<	0.10	7.20	83.85	75.31	0.69	0.36	7.20	143.14	2105.42	10509.43
00940	CHLORI	30		68.00	7.00	19.81	1.54	23.26	16.87	14.82	19.81	26.49	34.40	40.21
&01030	CHROMI	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00950	FLUORI	30		1.80	0.10	0.46	3.58	0.73	0.28	0.19	0.46	1.08	2.33	3.71
&01046	IRON	4		90.00<	50.00	57.91	1.34	87.09	38.51	47.49	57.91	70.62	84.41	93.92
&01049	LEAD	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00925	MAGNES	30		170.00	17.00	86.54	2.25	117.08	63.97	50.07	86.54	149.59	244.69	328.42
&71890	MERCUR	4	<	1.00<	1.00<	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
&71851	NITRAT	4		3.00	0.46	1.11	2.73	4.46	0.27	0.56	1.11	2.18	4.01	5.78
&70507	PHOSPH	4		0.12<	0.10	0.10	1.10	0.12	0.09	0.10	0.10	0.11	0.12	0.12
&00935	POTASS	5		4.50	1.70	2.62	1.46	4.05	1.70	2.03	2.62	3.38	4.26	4.88
&01145	SELENI	4	<	10.00<	10.00<	10.00	1.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
00955	SIL DI	30		31.00<	0.10	18.10	1.78	22.43	14.61	12.28	18.10	26.69	37.84	46.63
00930	SODIUM	30		380.00	150.00	243.36	1.23	263.20	225.02	211.17	243.36	280.46	318.63	343.89
00945	SULFAT	30		1000.00	89.00	431.60	1.67	523.08	356.12	304.73	431.60	611.28	835.94	1008.02
&00746	SULFID	4	<	0.20<	0.10<	0.17	1.41	0.27	0.10	0.13	0.17	0.21	0.26	0.30
&01090	ZINC	4		500.00<	100.00	149.53	2.24	456.91	48.94	86.86	149.53	257.42	419.55	561.88
# 00400	PH	22		8.90	7.00	7.85	0.45	8.04	7.65	7.54	7.85	8.15	8.42	8.59
00095	CONDUC	16		2300.00	1160.00	1439.59	1.31	1658.03	1249.92	1202.54	1439.59	1723.37	2026.03	2231.86
&00540	DIS SO	4		1600.00	910.00	1275.88	1.27	1783.03	912.97	1084.23	1275.88	1501.39	1738.04	1897.02
00410	ALKALI	28		570.00	285.00	400.79	1.21	430.98	372.72	353.12	400.79	454.90	509.76	545.69
&00720	CYANID	4	<	0.01<	0.01<	0.01	1.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
&01020	BORON	4		180.00<	100.00	115.83	1.34	174.17	77.03	94.99	115.83	141.24	168.83	187.84
&00681	DOC	3		16.00	6.00	11.54	1.76	32.65	4.08	7.87	11.54	16.91	23.85	29.29
&00613	NITRIT	4	<	0.01<	0.01<	0.01	1.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
&71870	BROMID	4		0.15<	0.10	0.11	1.22	0.15	0.08	0.10	0.11	0.13	0.14	0.15
&00340	C.O.D.	4		20.00	2.50	11.89	2.83	50.35	2.81	5.89	11.89	23.99	45.10	65.77
&32730	PHENOL	4		40.00<	1.00	9.46	4.96	87.29	1.02	3.21	9.46	27.87	73.67	131.74
&01080	STRONT	4		2700.00	900.00	1889.91	1.66	3812.79	936.78	1343.42	1889.91	2658.70	3613.81	4341.90

Table 5-13. (Continued)

COREHOLE WATER STATISTICAL ANALYSIS

REPORT TYPE :A AQUIFER :U SPEC SAMPLES DATE 07/12/79

PARAMETER DESCRIPTION	NUMBER	MAXIMUN	MINIMUN	MEAN	STD. DEV.	95% C.L.(U-L)		25%	50%	75%	90%	95%
# 00011 TEMPER	29	58.10	33.80	50.09	3.66	51.48	48.70	47.62	50.09	52.55	54.77	56.10
# 00003 DEPTH	28	627.62	12.10	282.55	246.71	378.04	187.06	116.02	282.55	449.08	598.83	688.39

END OF AQUIFER U SAMPLES REPORTING PERIOD IS 120178. THRU 53179.

---

* -- ESTIMATE USING METHOD OF MOMENTS
# -- NO LOG TRANSFORM
& -- BESTFIT IS ONLY AN ESTIMATE

Table 5-14. Summary of Statistical Tests for Upper and Lower Aquifer Holes, Tract C-a

Hole	AM-3			G-S M1			G-S M2			G-S M3			G-S M4			G-S 15U			G-S 15L		
Test	t	F	t'	t	F	t'	t	F	t'	t	F	t'	t	F	t'	t	F	t'	t	F	t'
Parameter																					
Alkalinity	+	+	f		+		+	+	p	+			+								
Calcium	+									+						+					
Carbonate	+									+	+	f					+	p		+	p
Chloride					+	p										+					
Fluoride	+	+	f					+	p		+	p				+					
Magnesium	+				+	p		+	p		+	f		+	p	+				+	p
Silica	+	+	f											+	p		+	p			
Sodium					+	+								+	p						
Sulfate		+	p							+						+					
pH	+			+			+	+	f	+			+			+					
Conductivity	+			+												+					
Temperature		+	p		+	p															+
Depth (water level)		+	p	+	+	p		+	p		+	p								+	p

+ Failed statistical test as indicated

p Passed t'-test

f Failed t'-test

The large number of constituents exhibiting significant differences from baseline (Table 5-14) reinforces the position that the rejection of a null hypothesis does not necessarily represent a development-related impact. Control stations were affected as often as were treatment stations. In view of these tests it appears appropriate that the following steps be taken:

1) Continued surveillance and reevaluation after additional data are available;
2) More stringent quality control to improve the accuracy of data;
3) Evaluation of the "ecological significance" of water quality changes as sufficient data become available.

The trilinear diagram (Figure 5-28) for the 1978-1979 upper aquifer data is consistent with the data presented in the baseline report. There are no values which lie outside the pattern or the area of the trilinear diagram presented in the FEBR.

5.3 OPERATIONAL MONITORING

Hydrologic data collected in compliance with permit stipulations are reported on a regular basis in permit reports and are not repeated herein. Data collected in response to AOSO requirements for special tests and other operational activities are likewise reported in special reports on a regular basis and are not discussed here. Data are provided in Appendix 5-3 for reference.

5.4 SUMMARY AND CONCLUSIONS

The present statistical treatment of data collected during the December 1978 through May 1979 reporting period has shown that a large number of constituents exhibit significant differences from baseline. However, the rejection of the various null hypotheses do not necessarily represent a development-related impact; control stations were affected as often as were treatment stations. As was stated in Section 5.2, RBOSC feels that the following steps should be taken:

- Continued surveillance and reevaluation after additional data are available;
- More stringent quality control to improve the precision of data;
- Evaluation of the "ecological significance" of water quality changes as sufficient data become available.

Figure 5-28. Trilinear Diagram of Combined (G-S M1, G-S M2, G-S M3, G-S M4, AM-3, G-S 15) Upper Aquifer Analyses for December 1978 to May 1979.

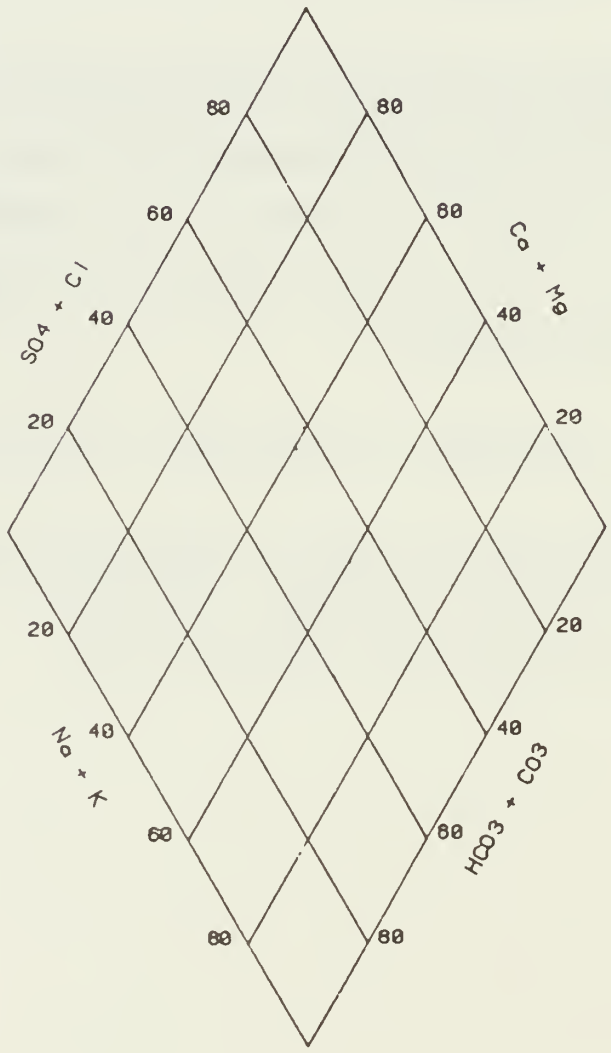


Figure 5-29. AM 3 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

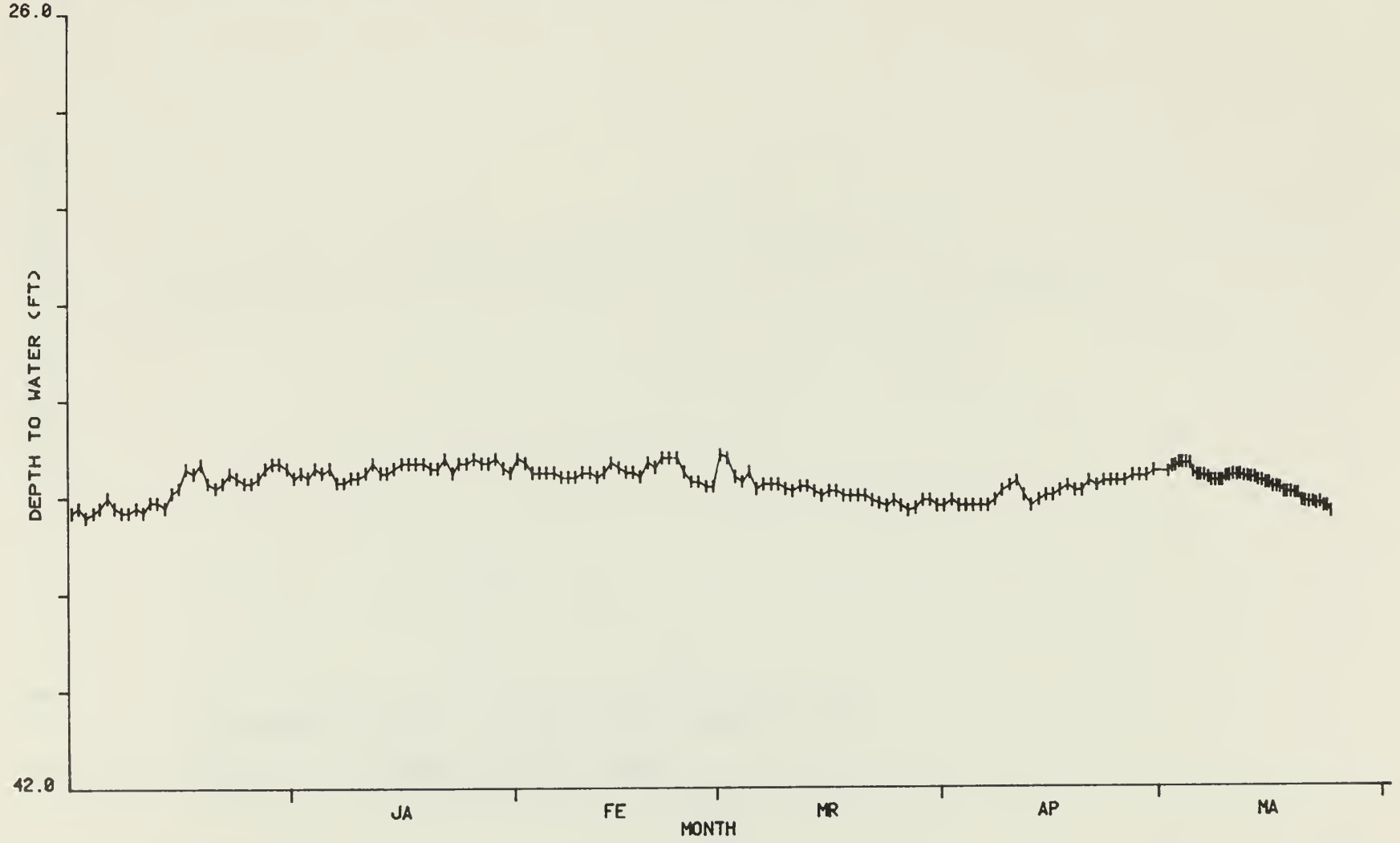


Figure 5-30. AM 3 CONDUCTIVITY DATA
DECEMBER 1978 — MAY 1979, TRACT C-A

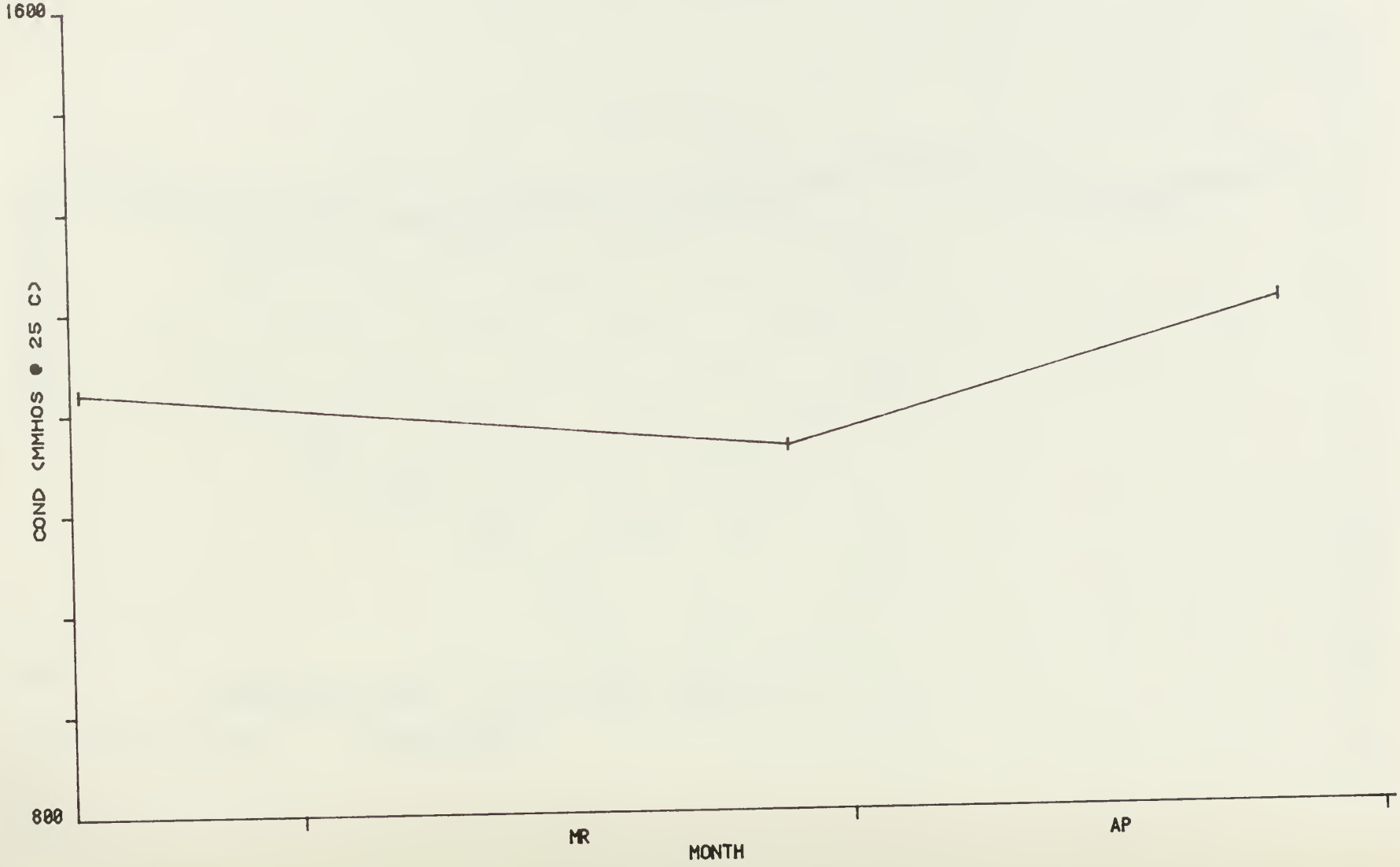


Figure 5-31. AM 3 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

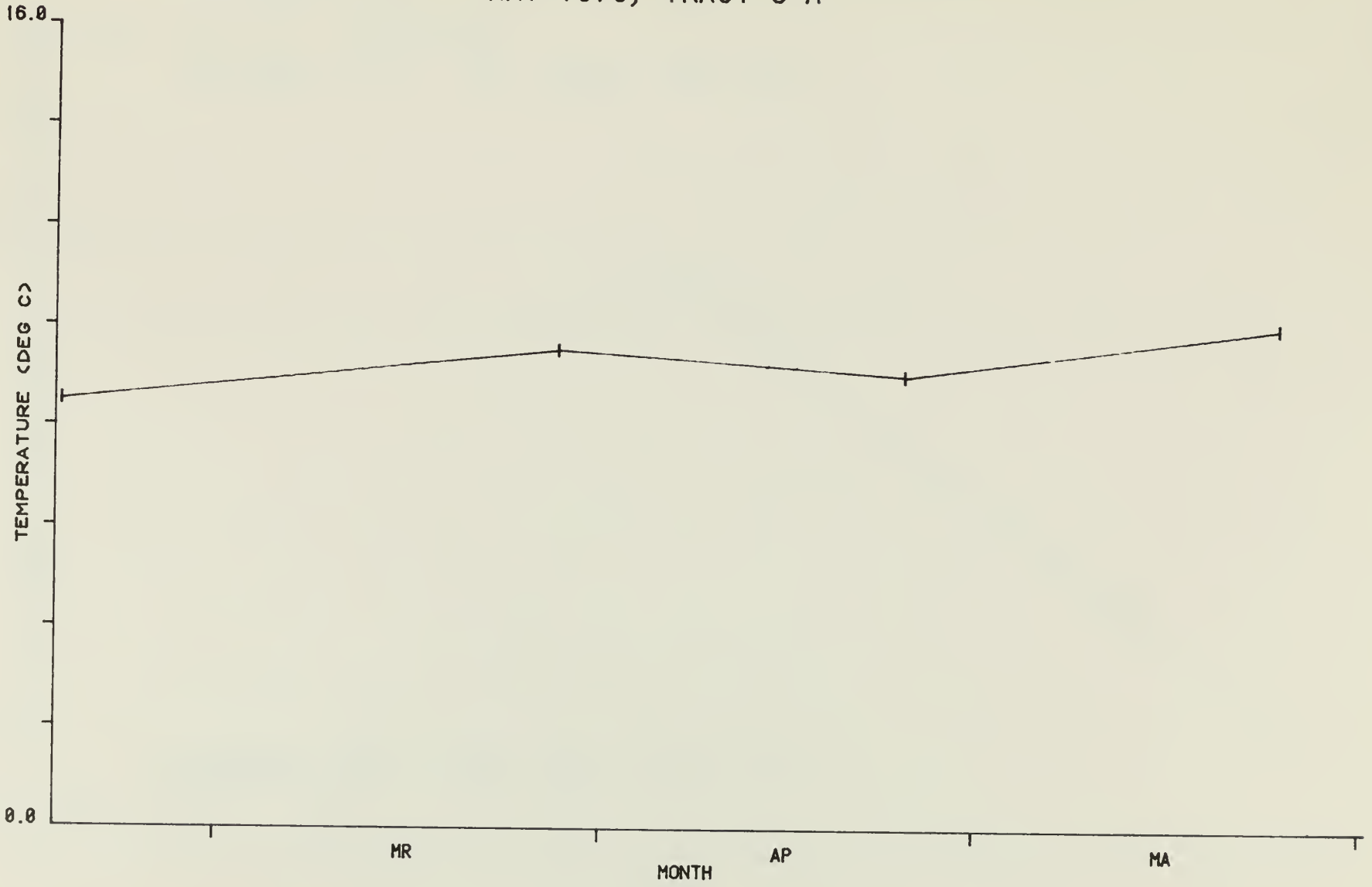


Figure 5-32.

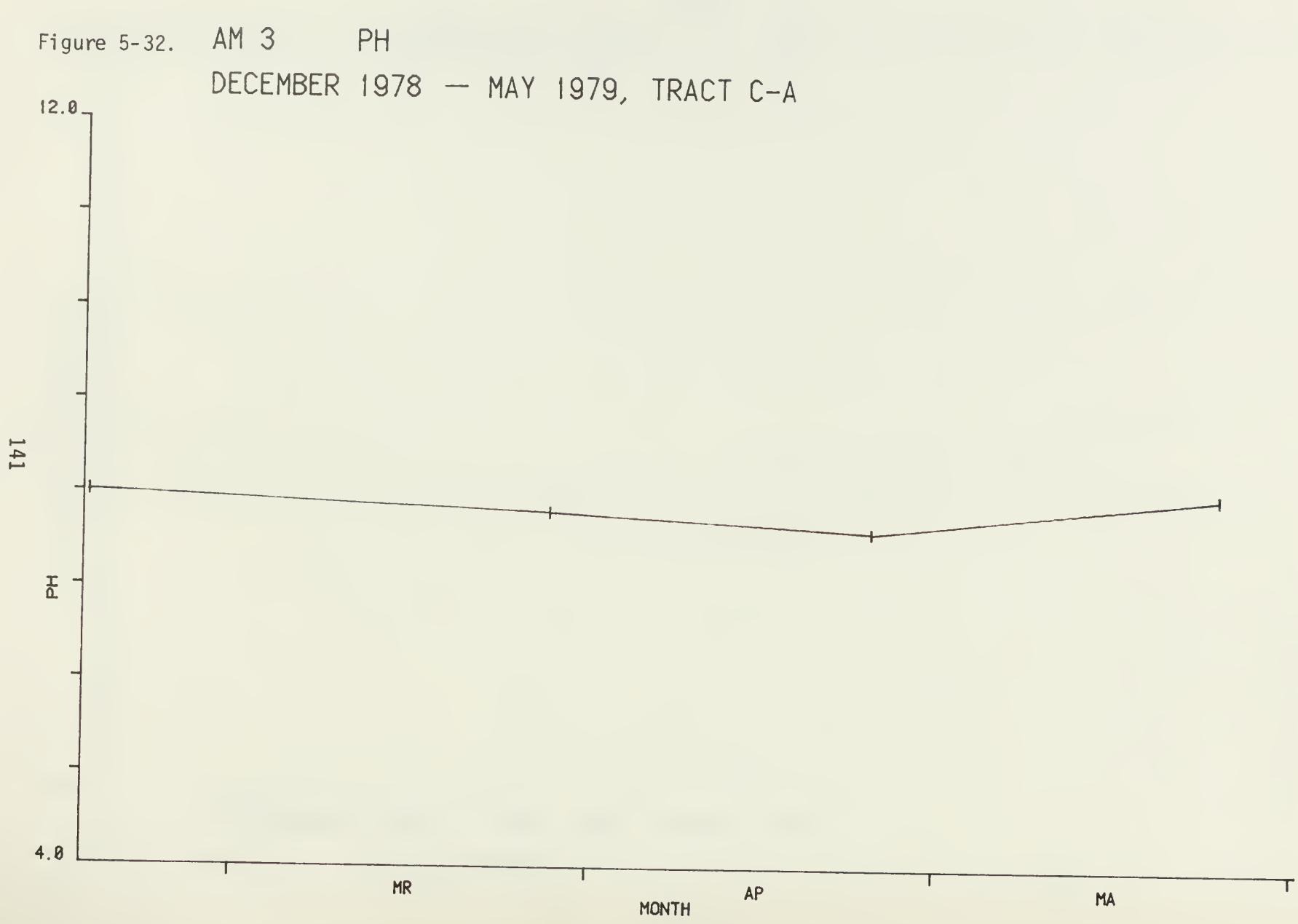

AM 3 PH
DECEMBER 1978 — MAY 1979, TRACT C-A
12.0
141
PH
4.0
MR
AP
MA
MONTH

Figure 5-33. G-S M1 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

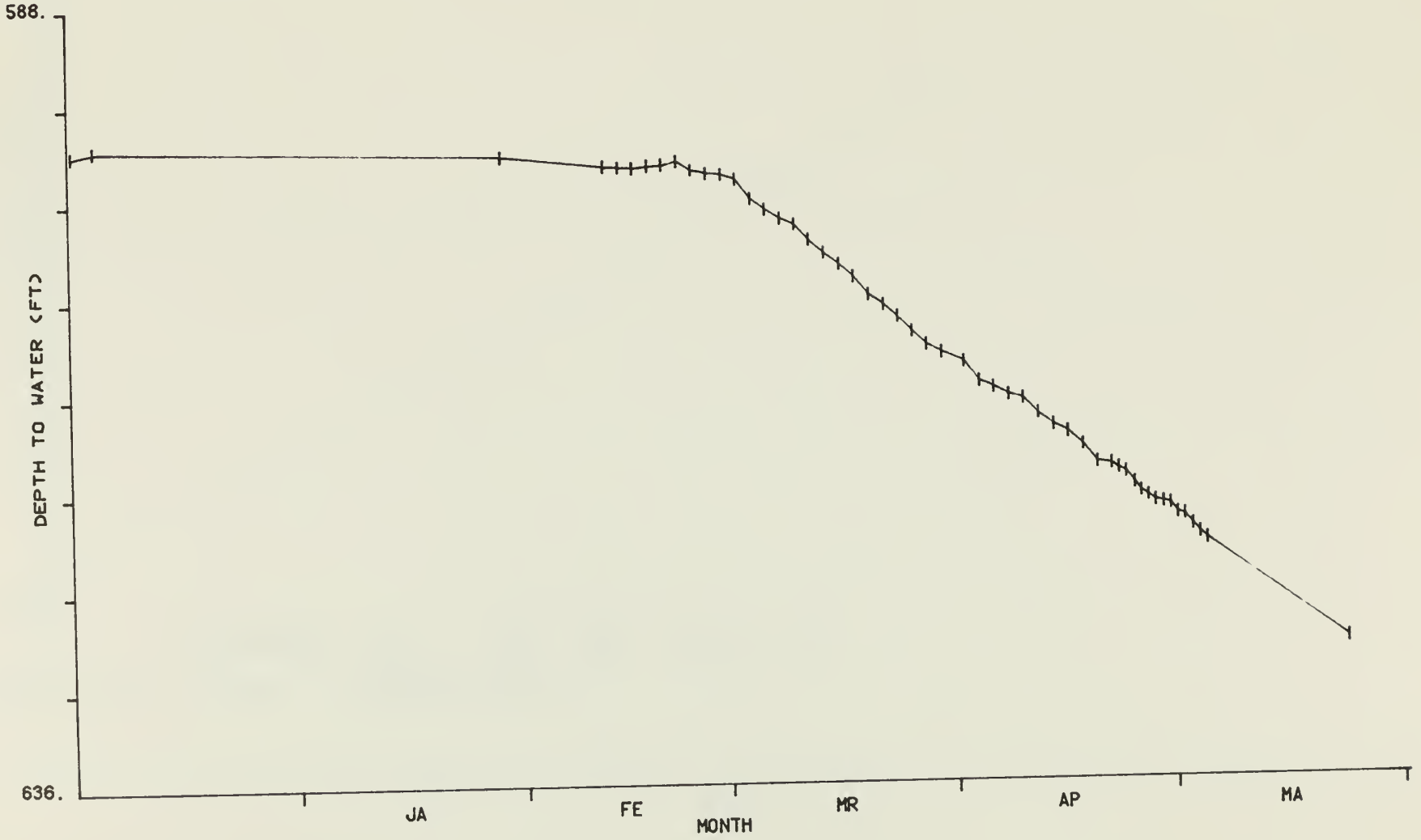


Figure 5-34. G-S M1 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

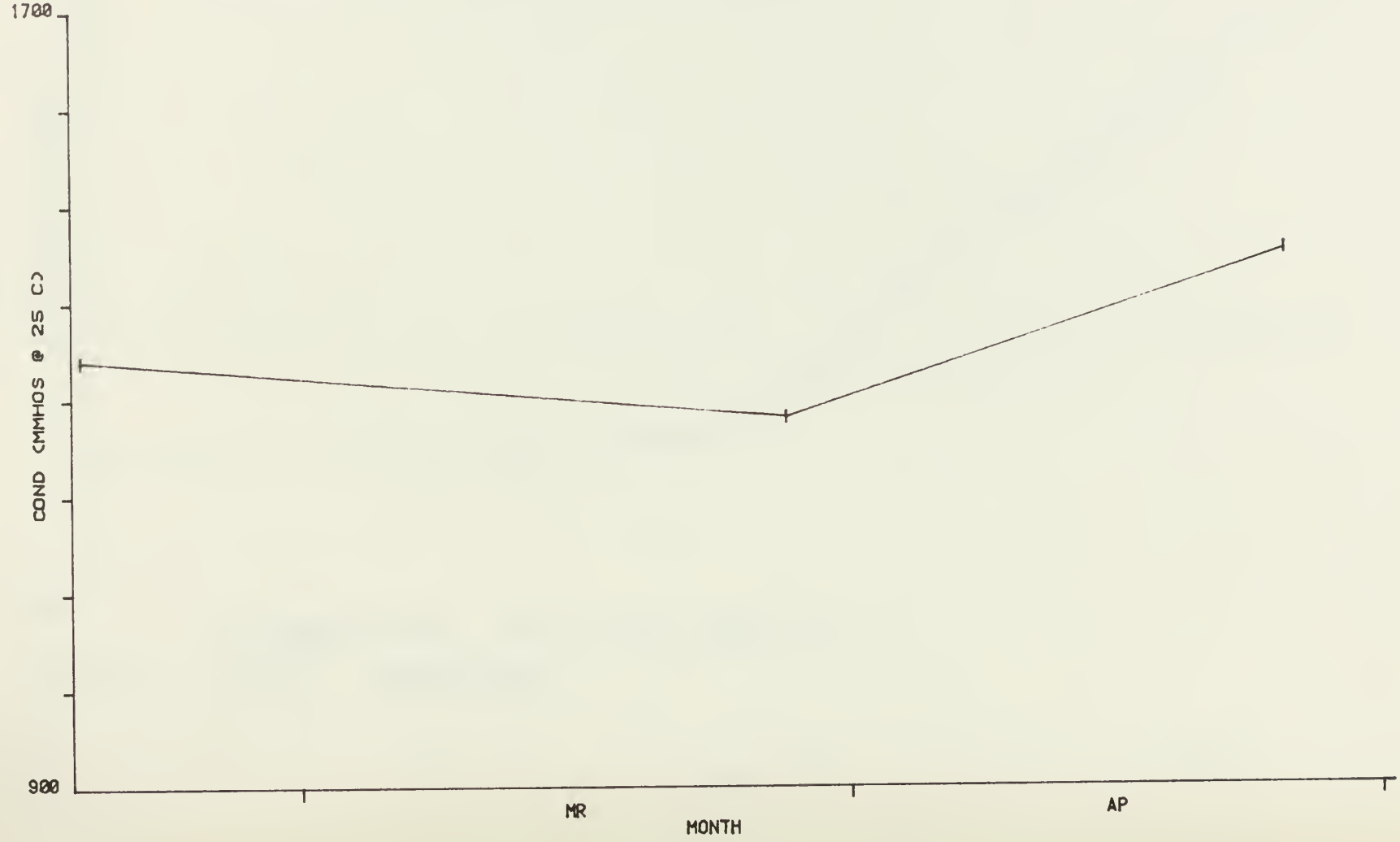


Figure 5-35. G-S M1 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

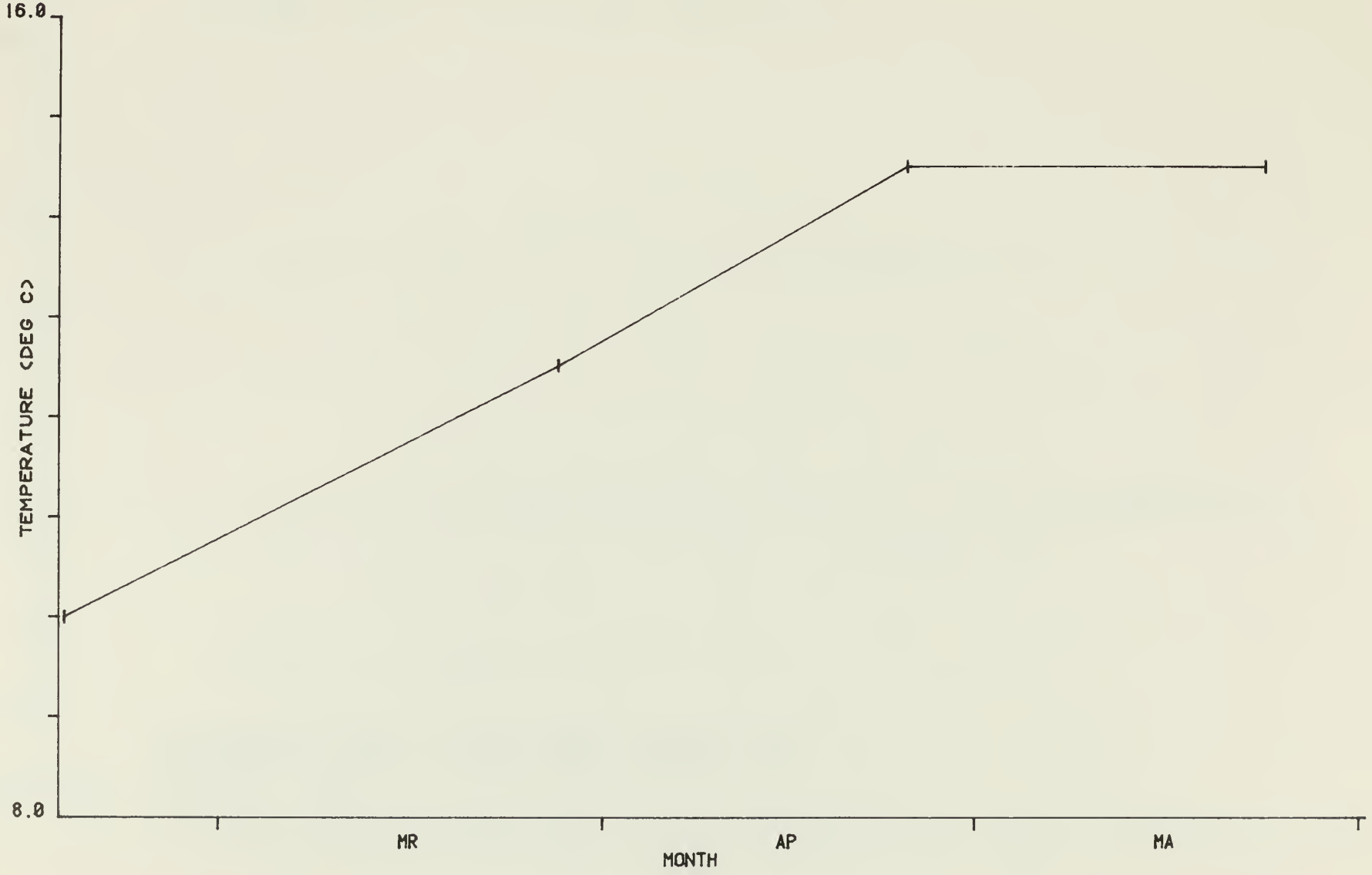


Figure 5-36. G-S M1 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

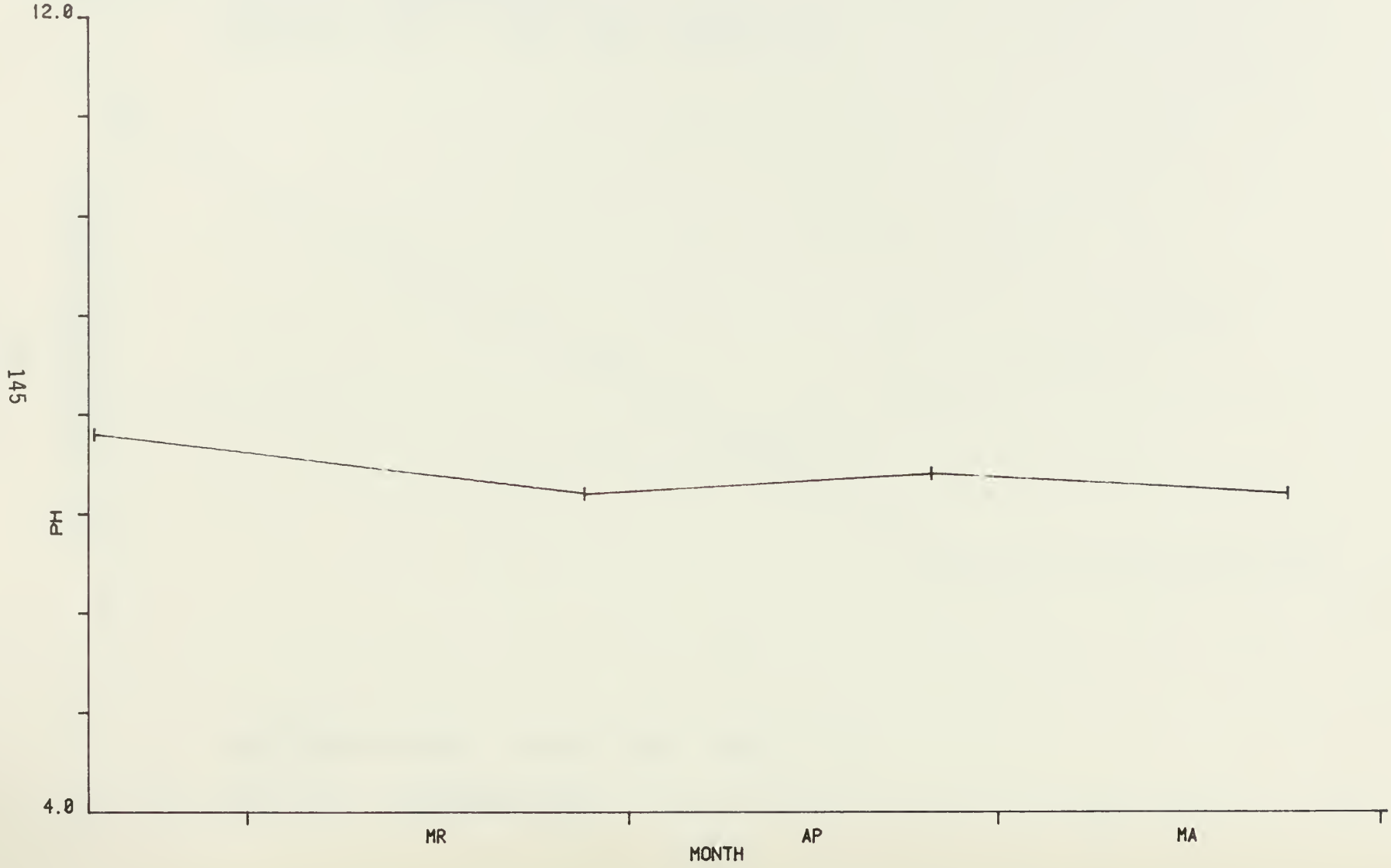


Figure 5-37. G-S M2 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

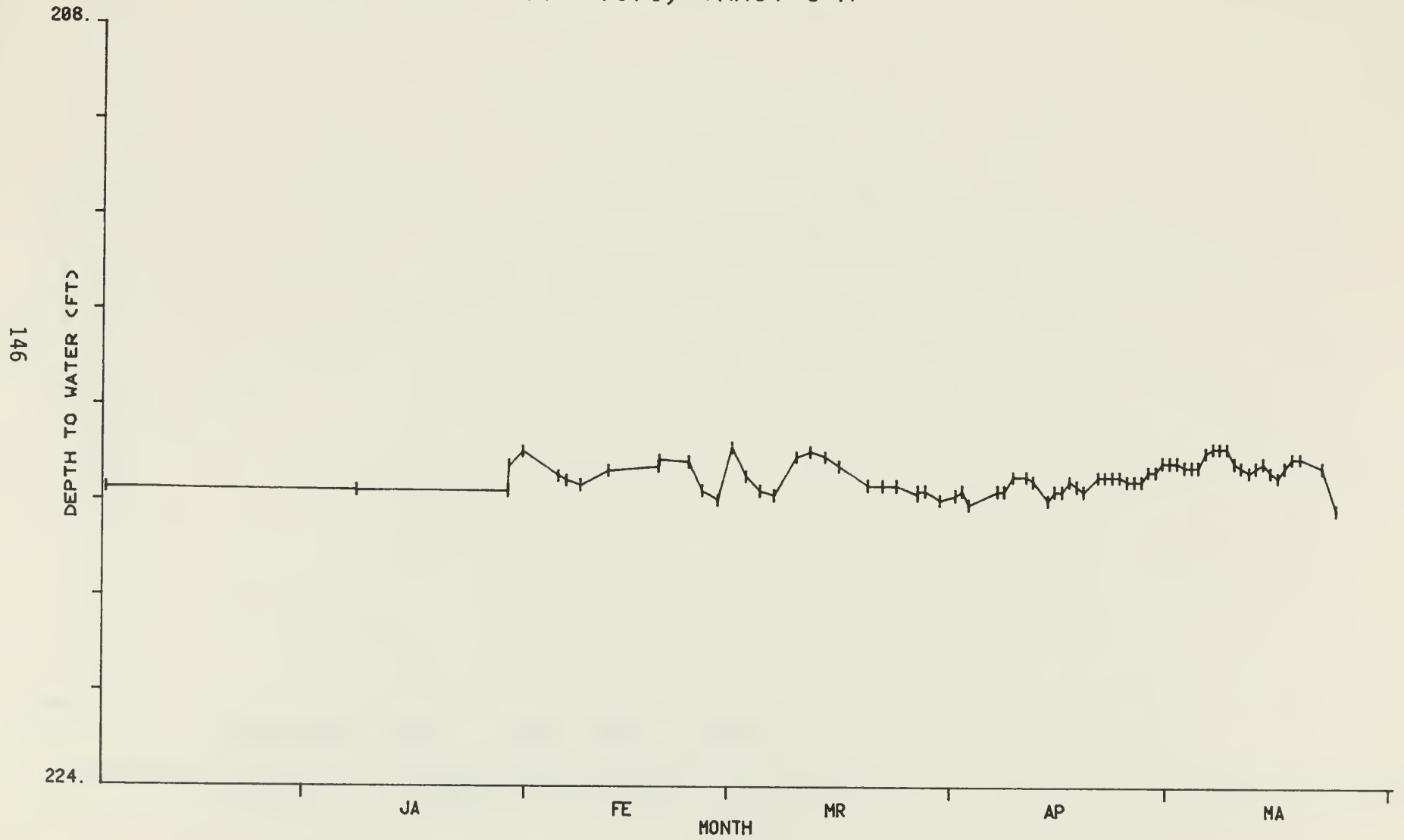


Figure 5-38. G-S M2 CONDUCTIVITY DATA
DECEMBER 1978 — MAY 1979, TRACT C-A

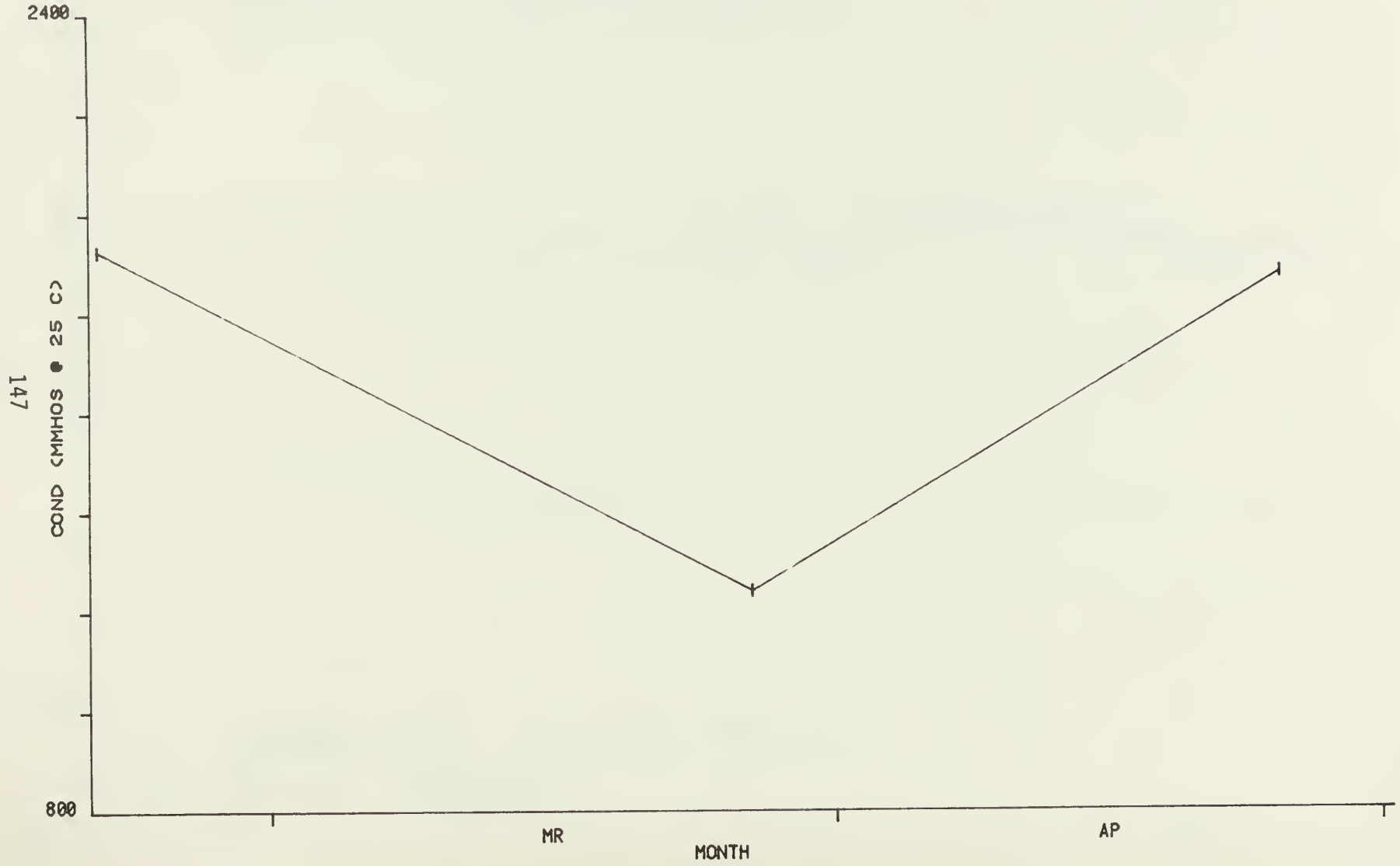


Figure 5-39. G-S M2 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

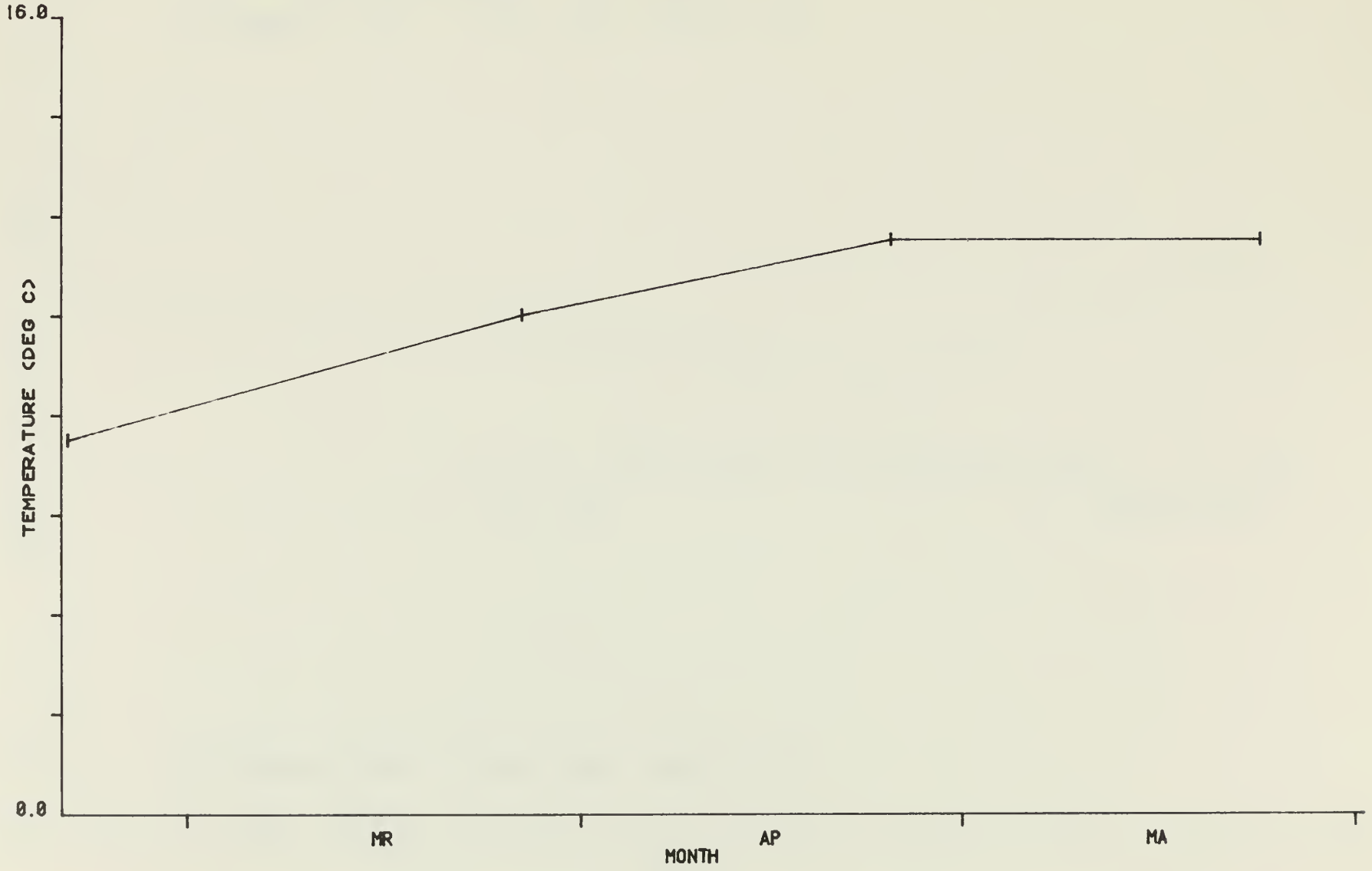


Figure 5-40. G-S M2 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

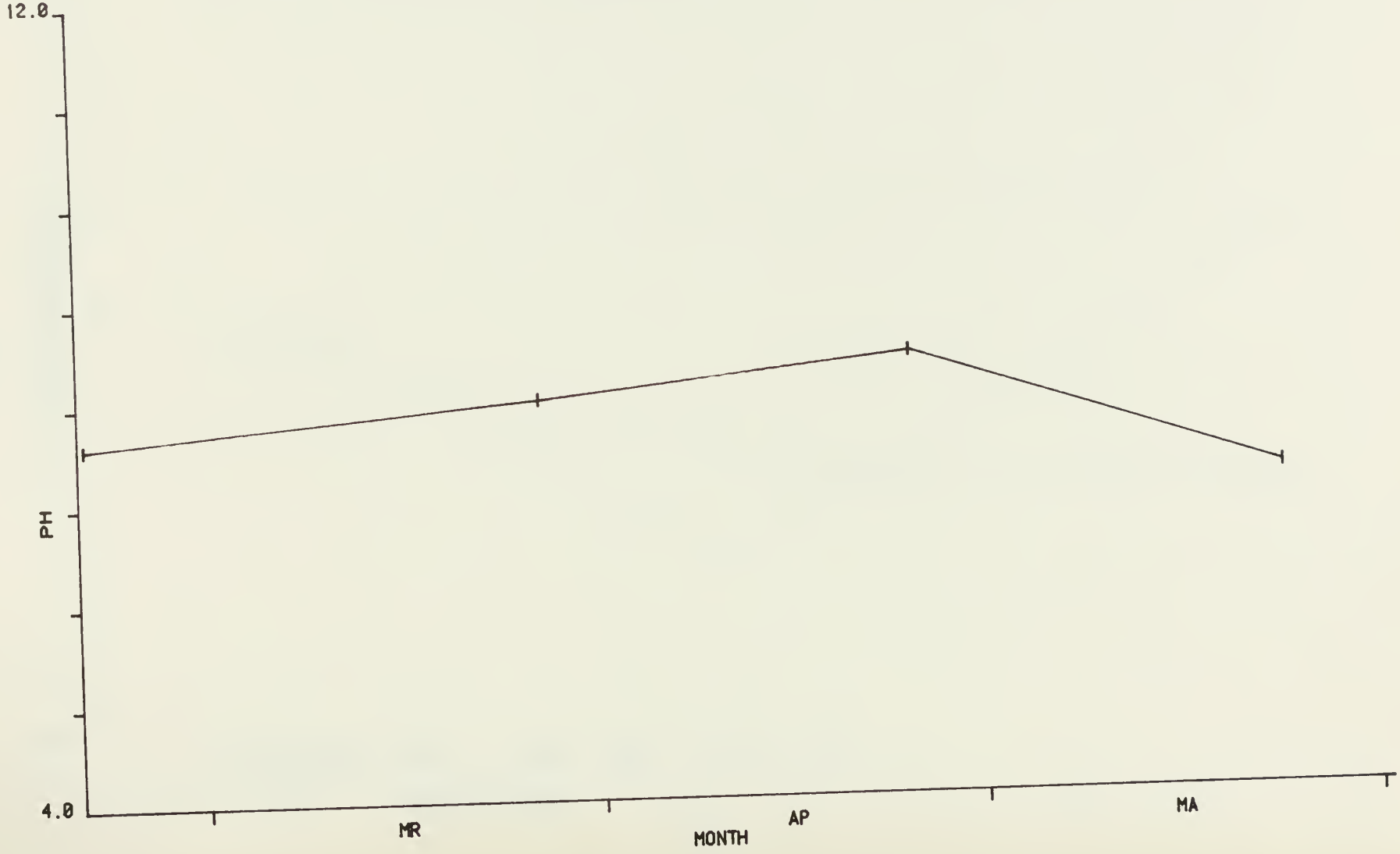


Figure 5-41. G-S M3 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

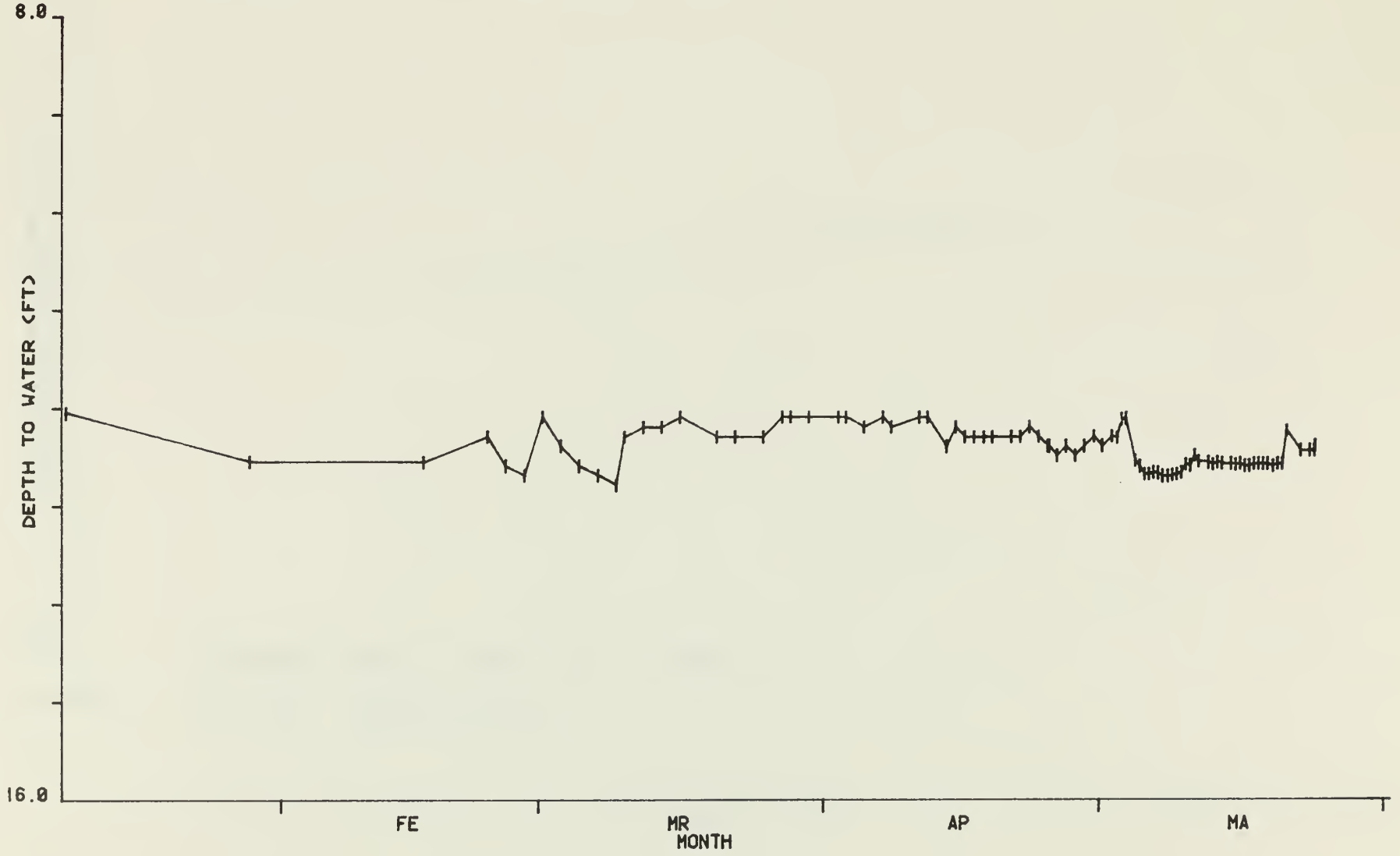


Figure 5-42. G-S M3 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

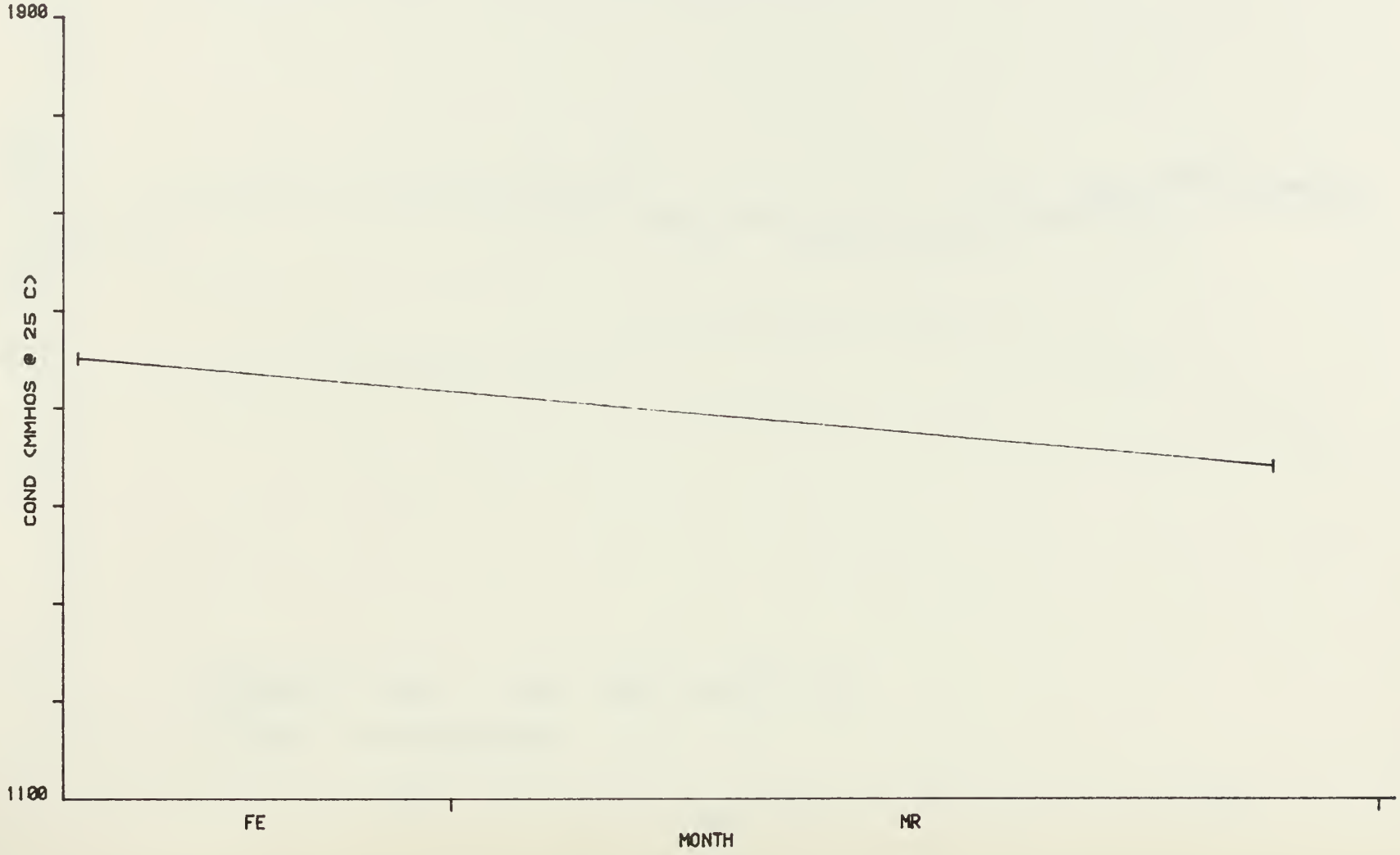


Figure 5-43. G-S M3 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

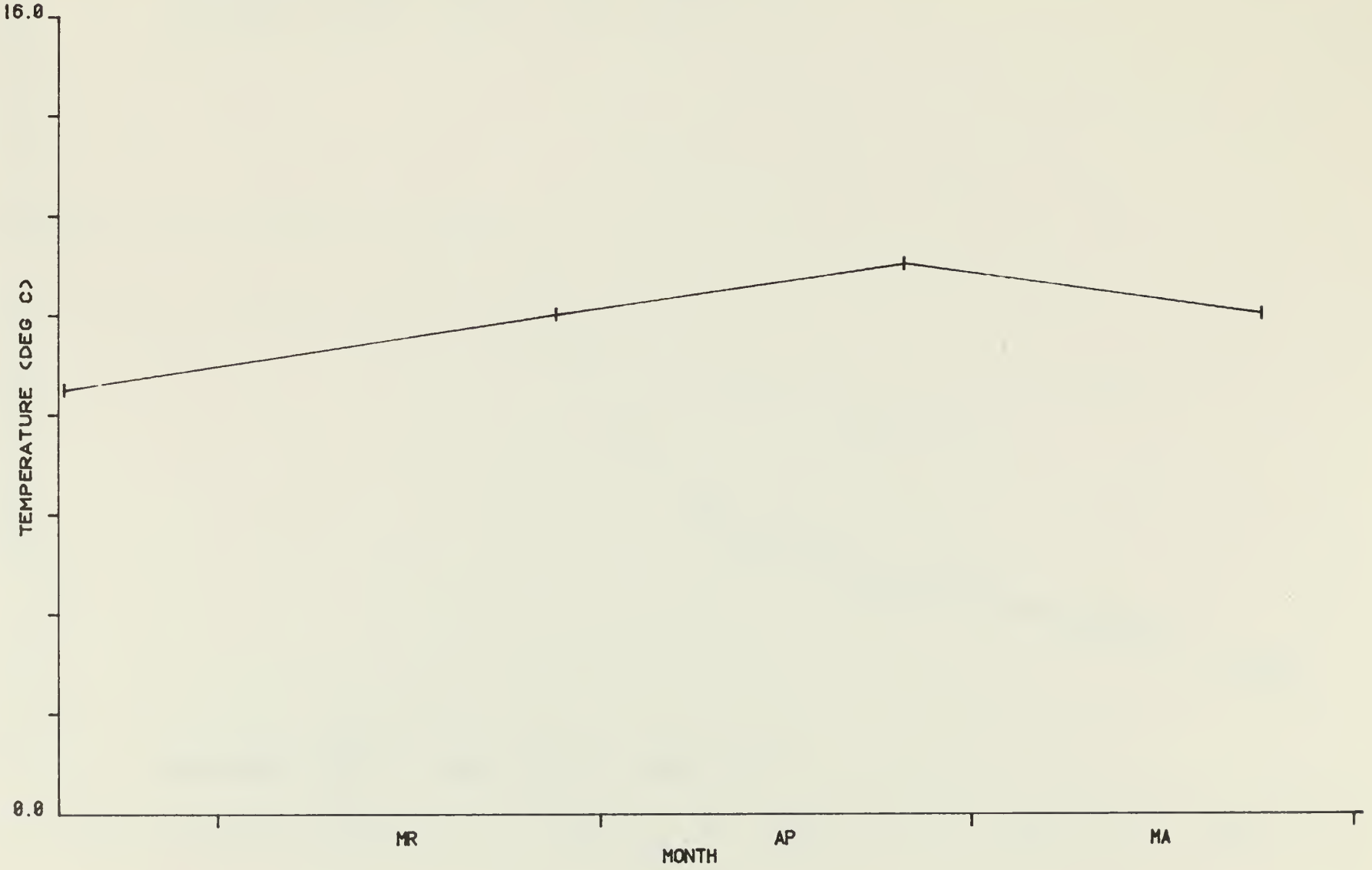


Figure 5-44. G-S M3 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

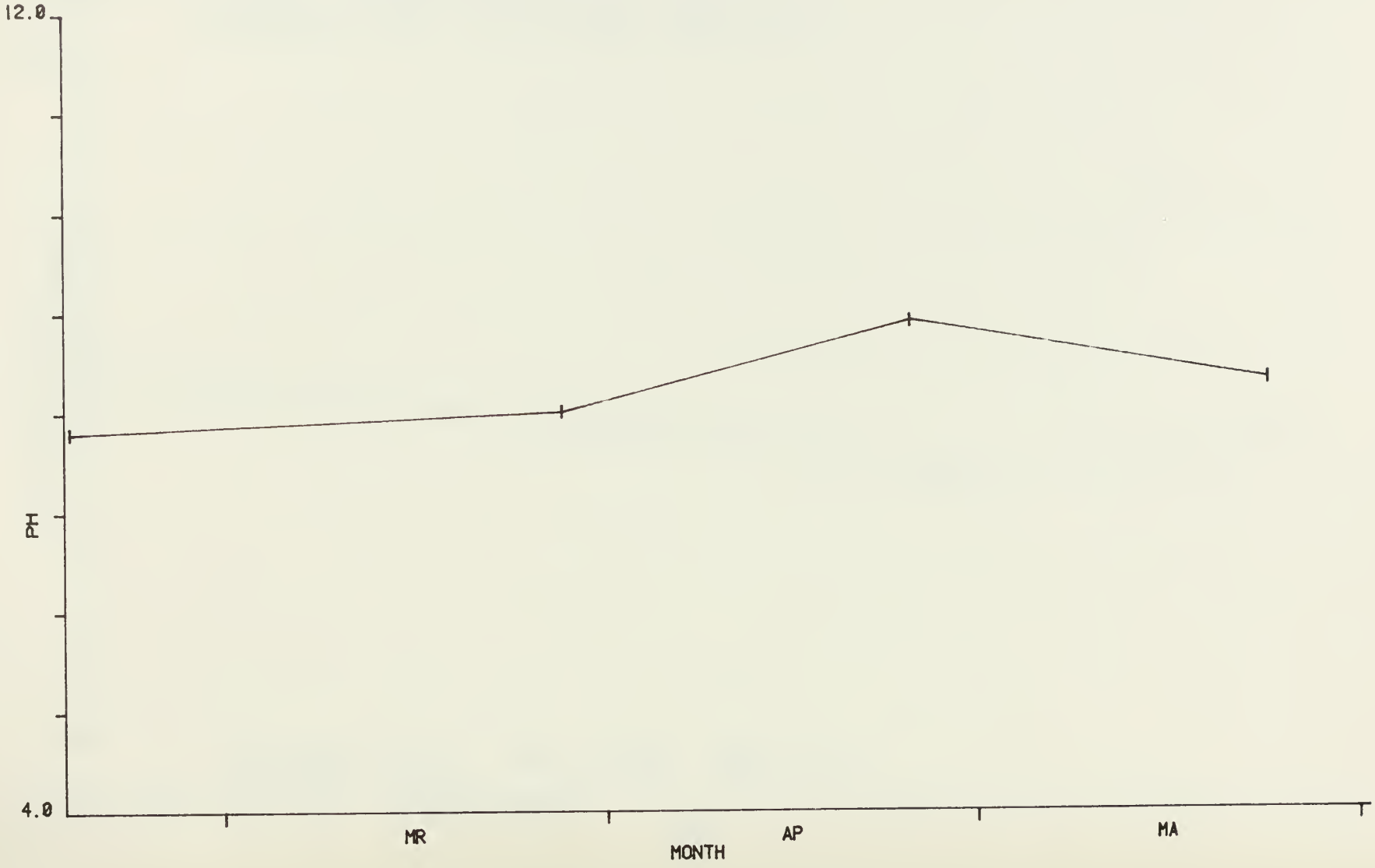


Figure 5-45. G-S M4 HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

Figure 5-46. G-S M4 CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

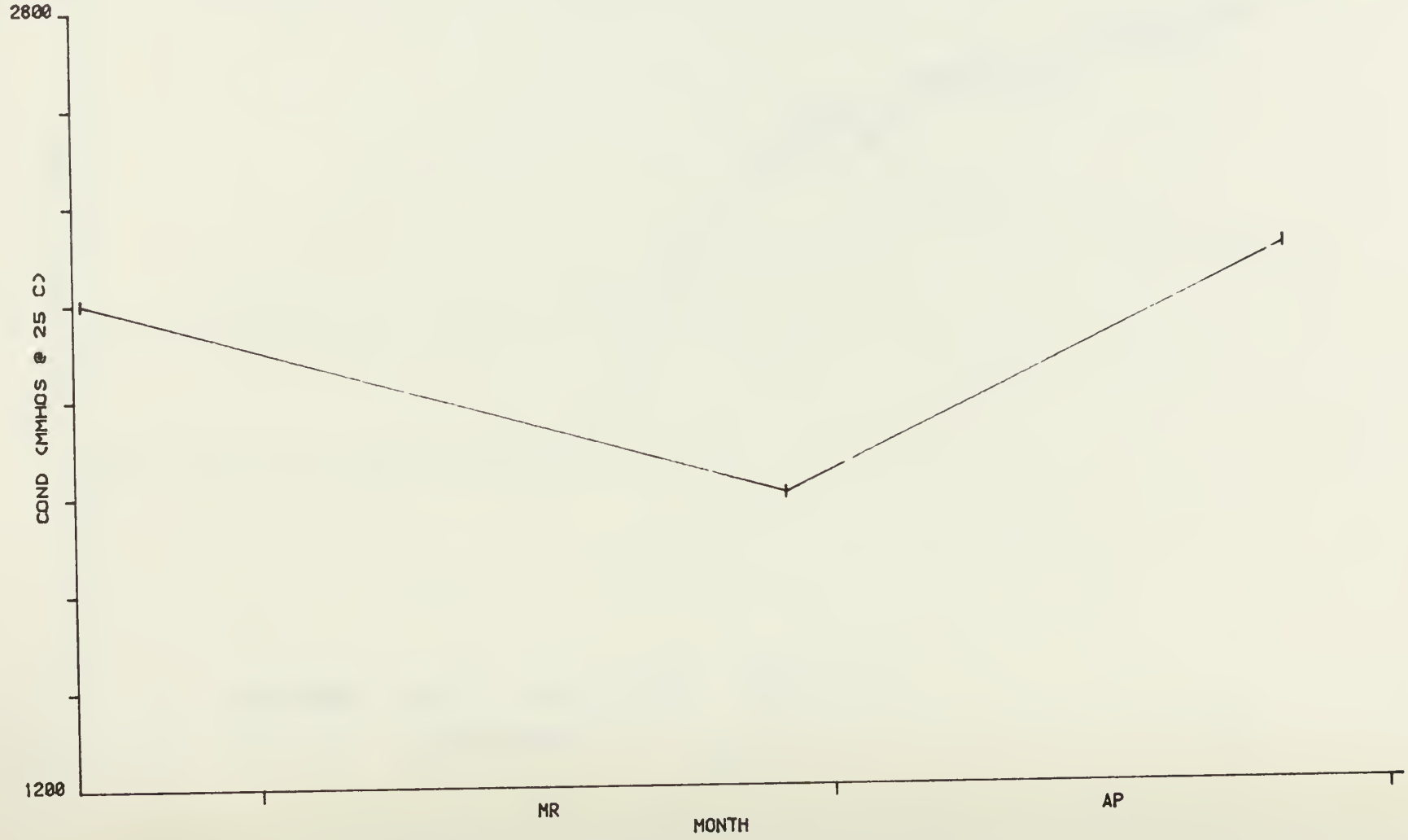


Figure 5-47. G-S M4 TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

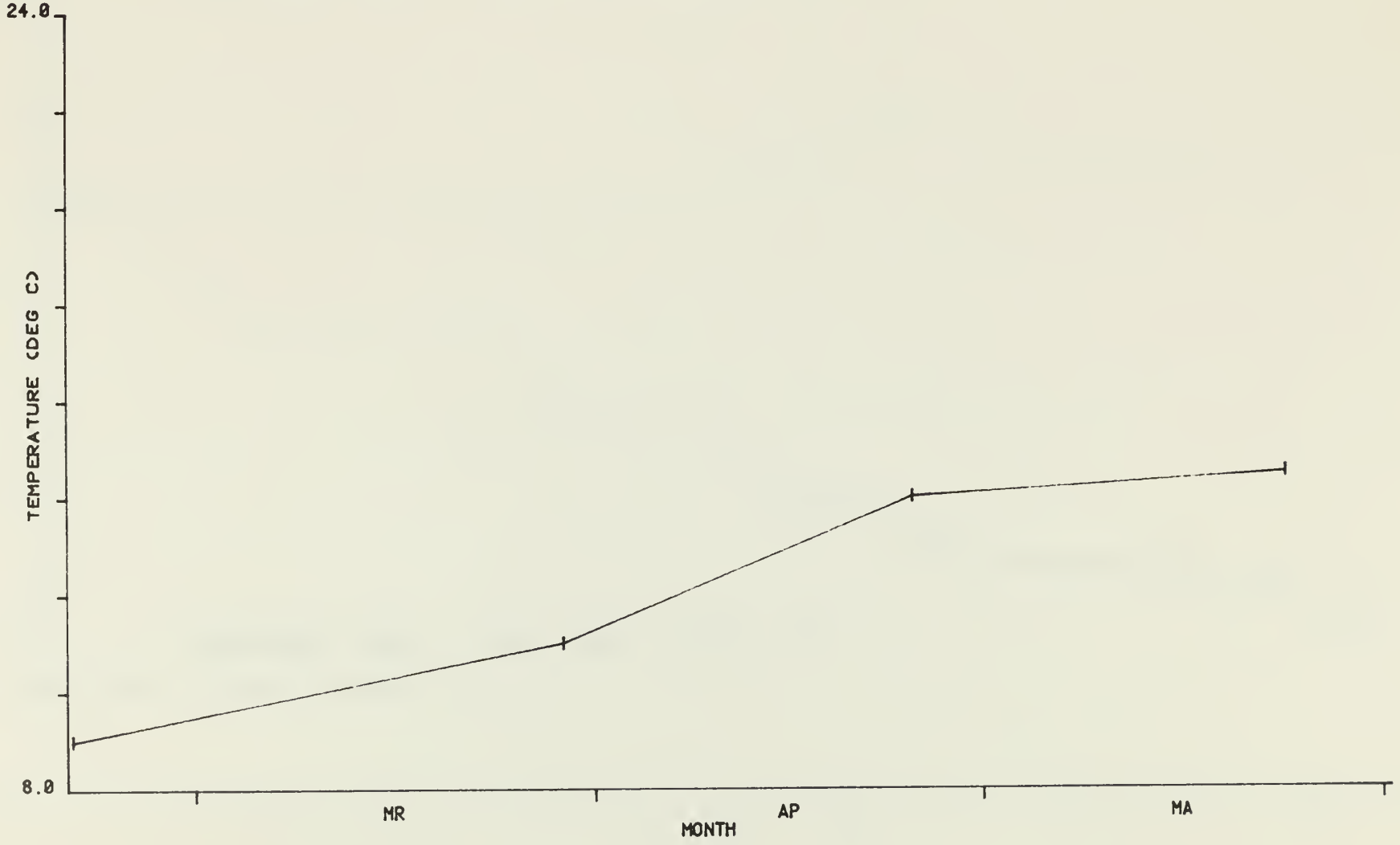


Figure 5-48. G-S M4 PH
DECEMBER 1978 — MAY 1979, TRACT C-A

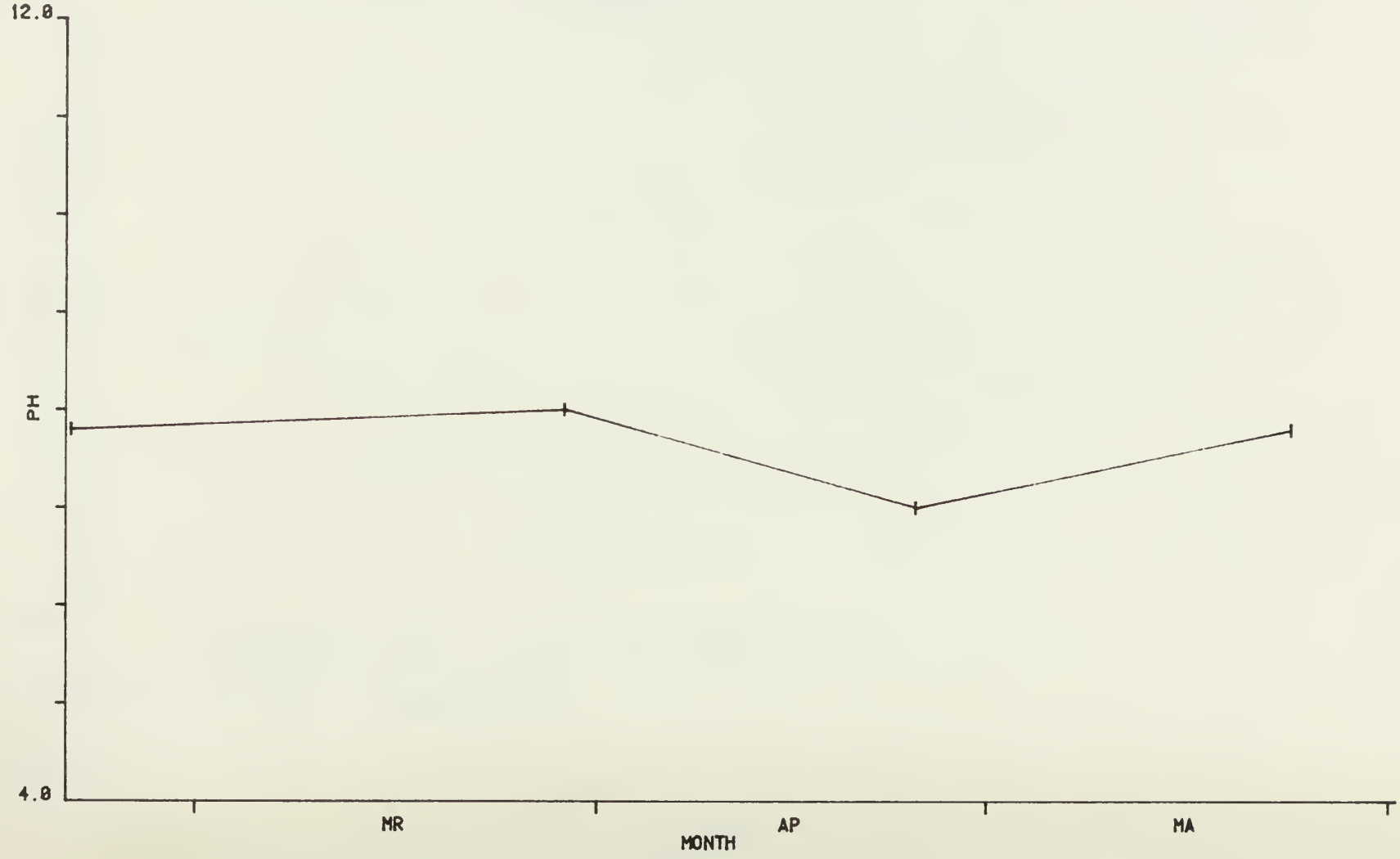


Figure 5-49. G-S 15U HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

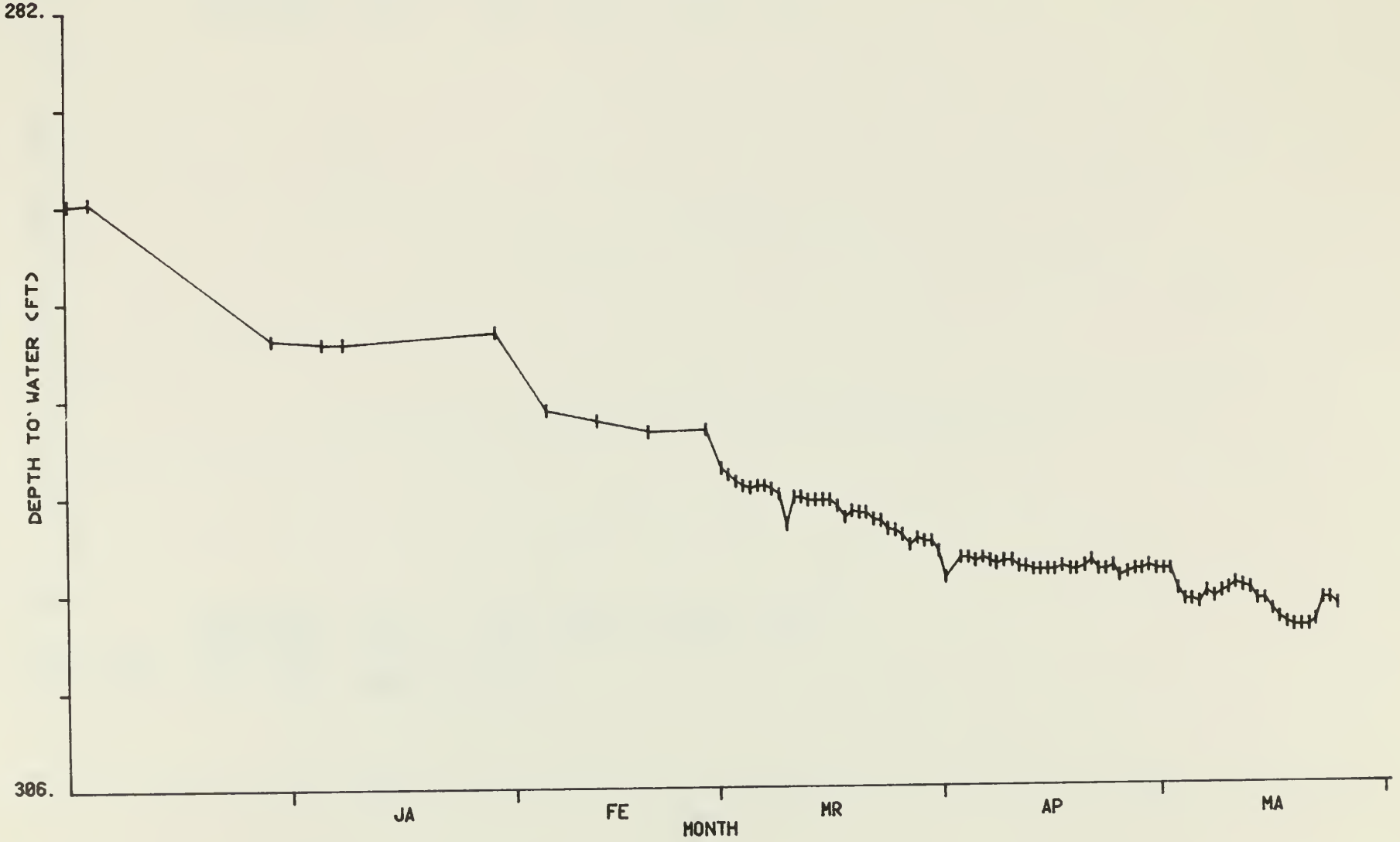


Figure 5-50. G-S 15U CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

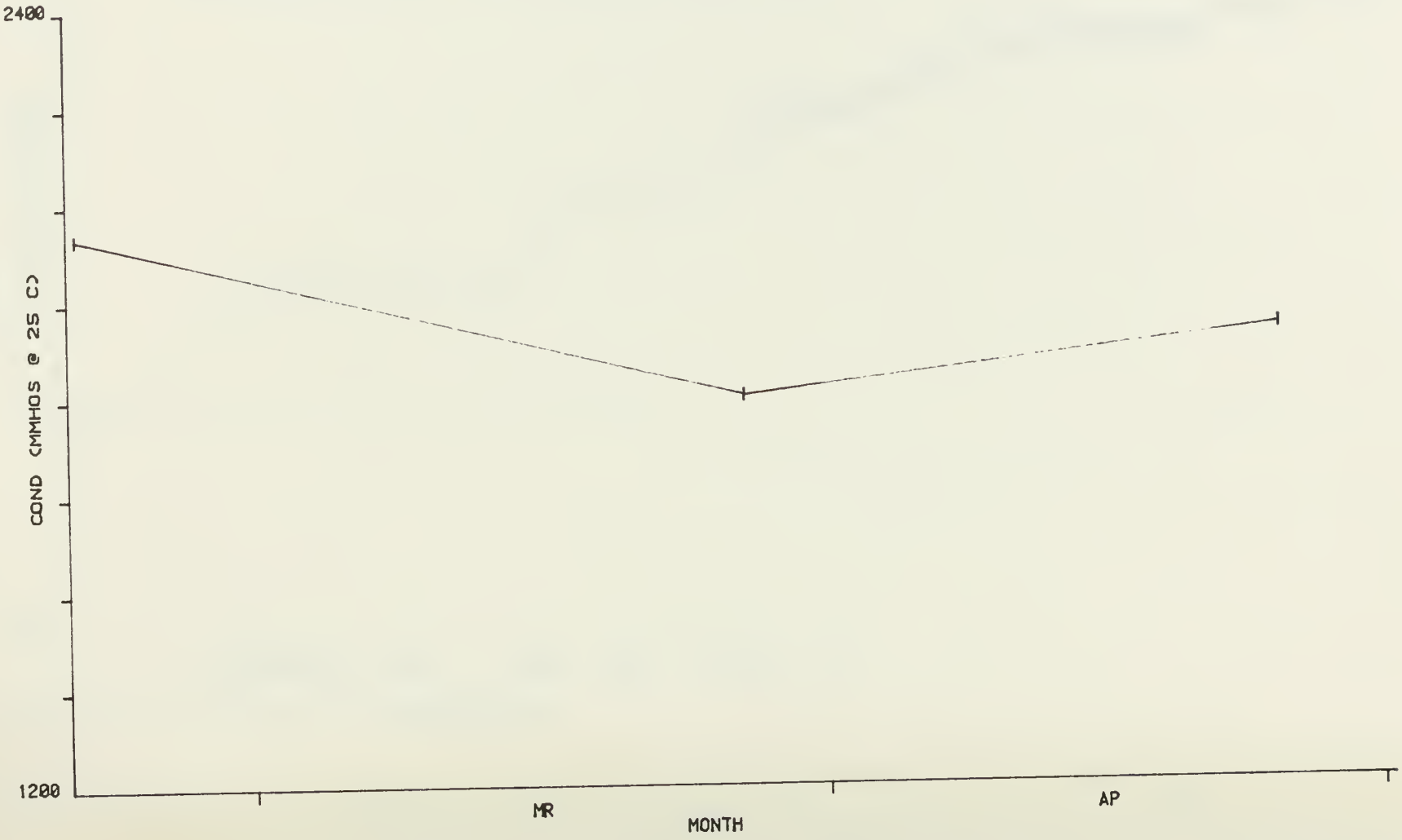


Figure 5-51. G-S 15U TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

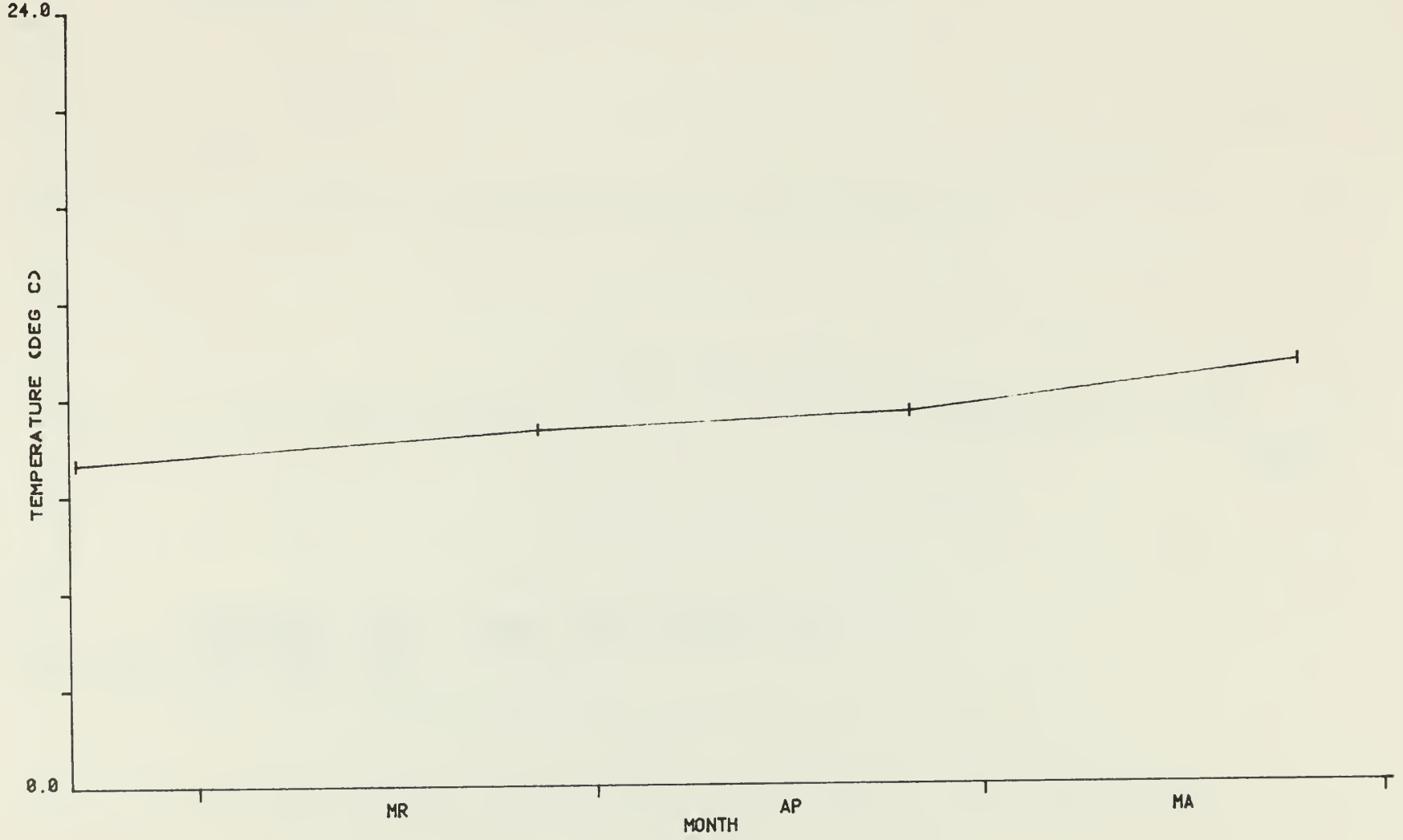


Figure 5-52. G-S 15U PH
DECEMBER 1978 — MAY 1979, TRACT C-A

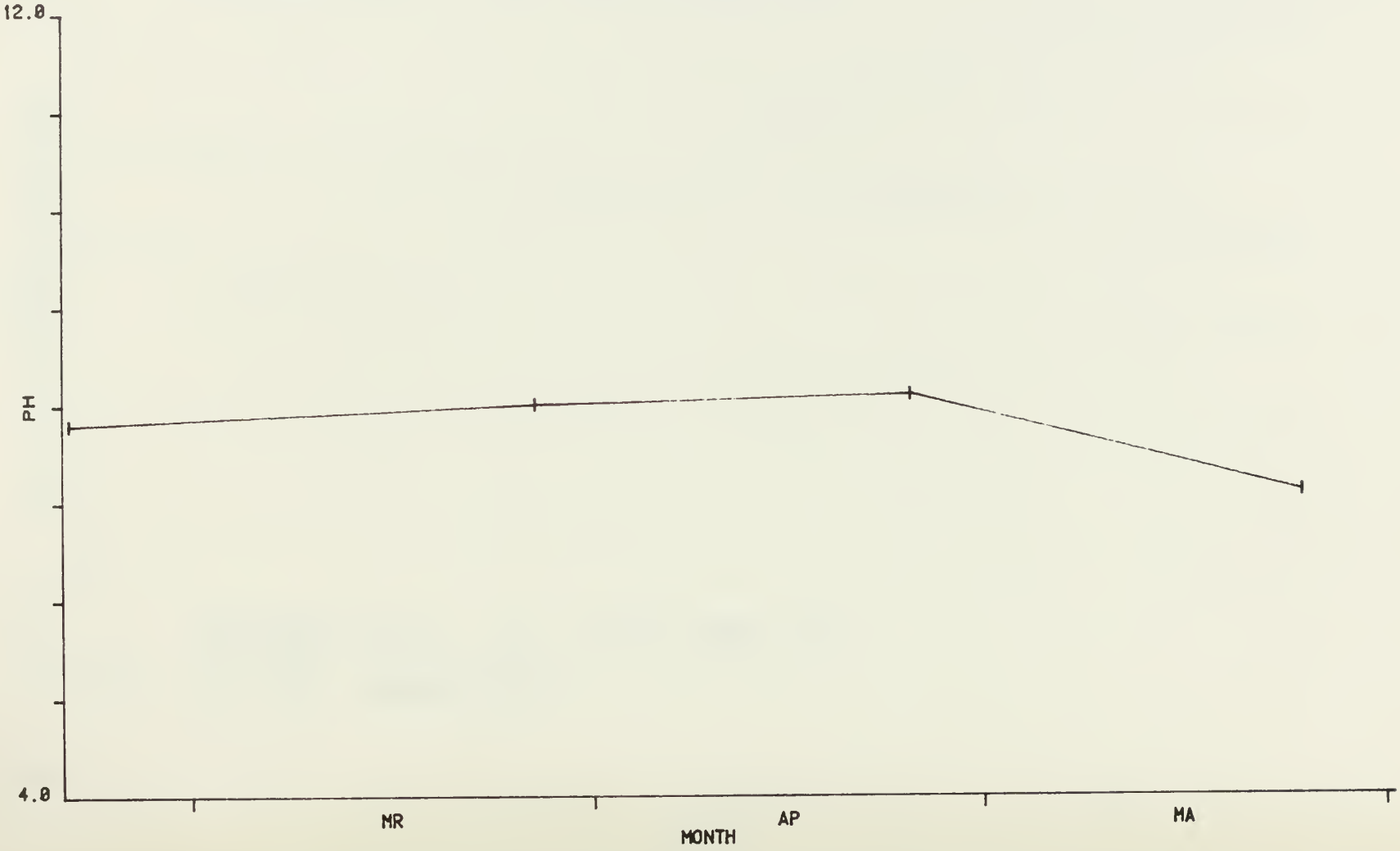


Figure 5-53. G-S 15L HYDROGRAPH
DECEMBER 1978 — MAY 1979, TRACT C-A

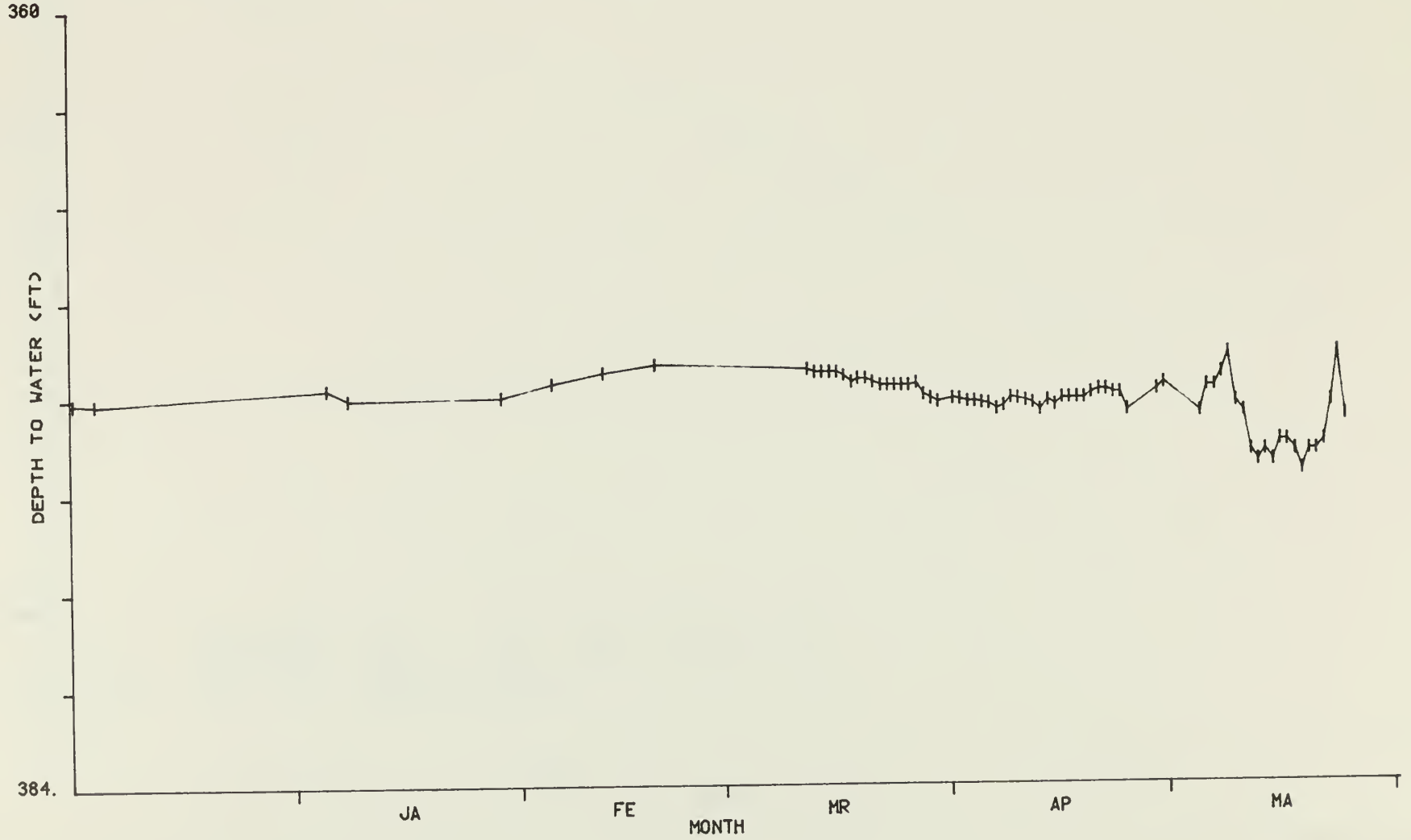


Figure 5-54. G-S 15L CONDUCTIVITY
DECEMBER 1978 — MAY 1979, TRACT C-A

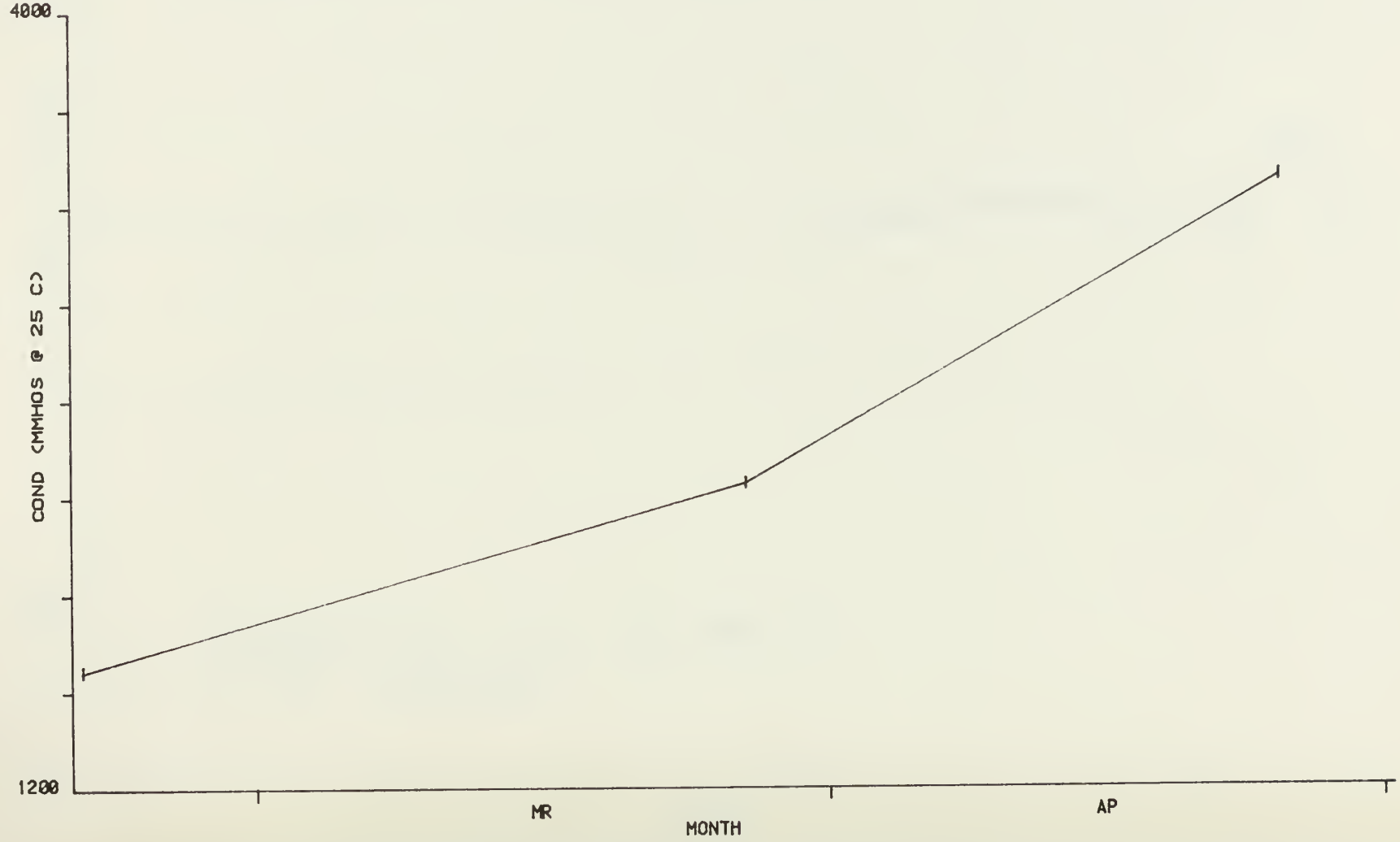


Figure 5-55. G-S 15L TEMPERATURE
DECEMBER 1978 — MAY 1979, TRACT C-A

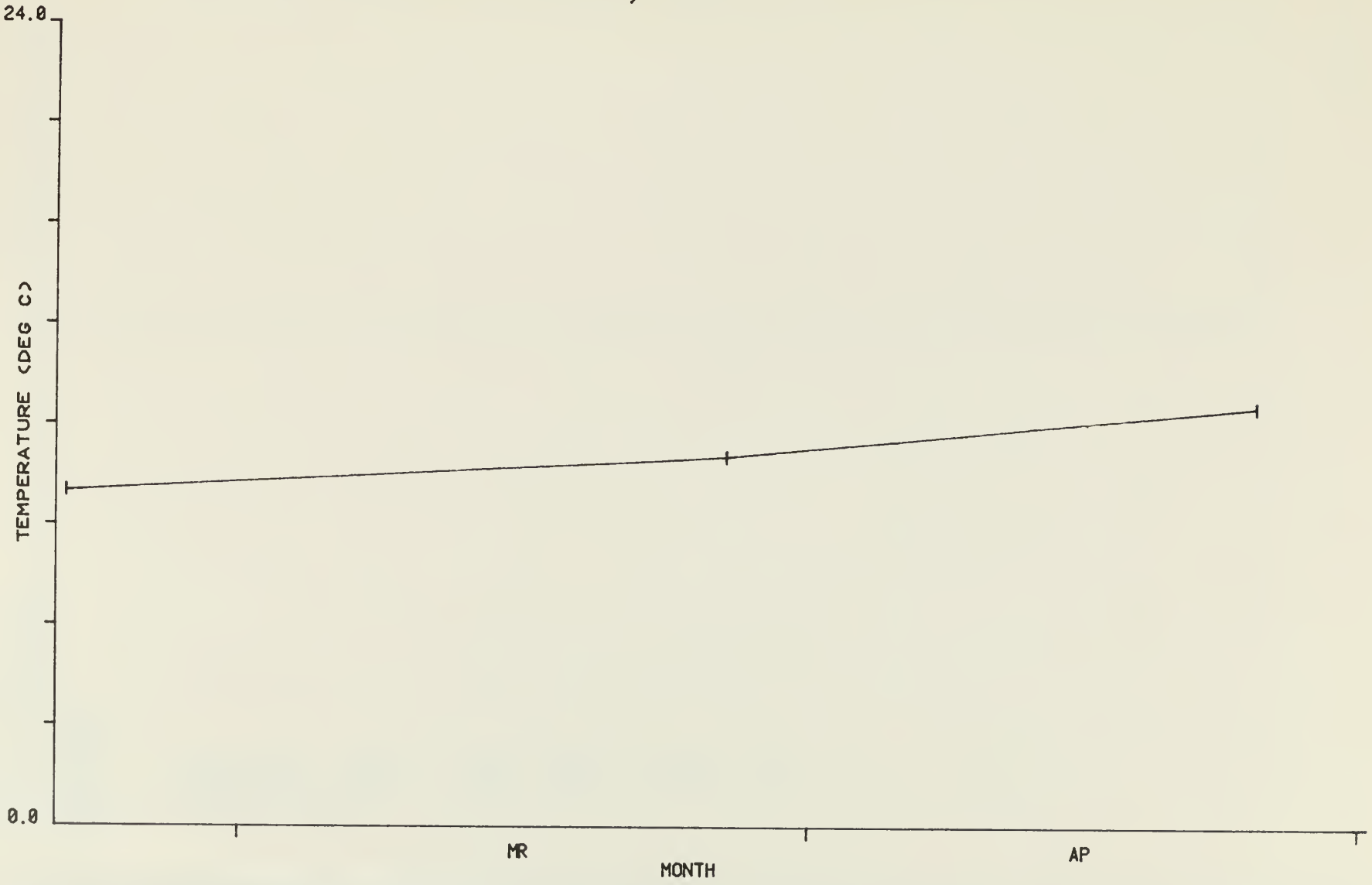
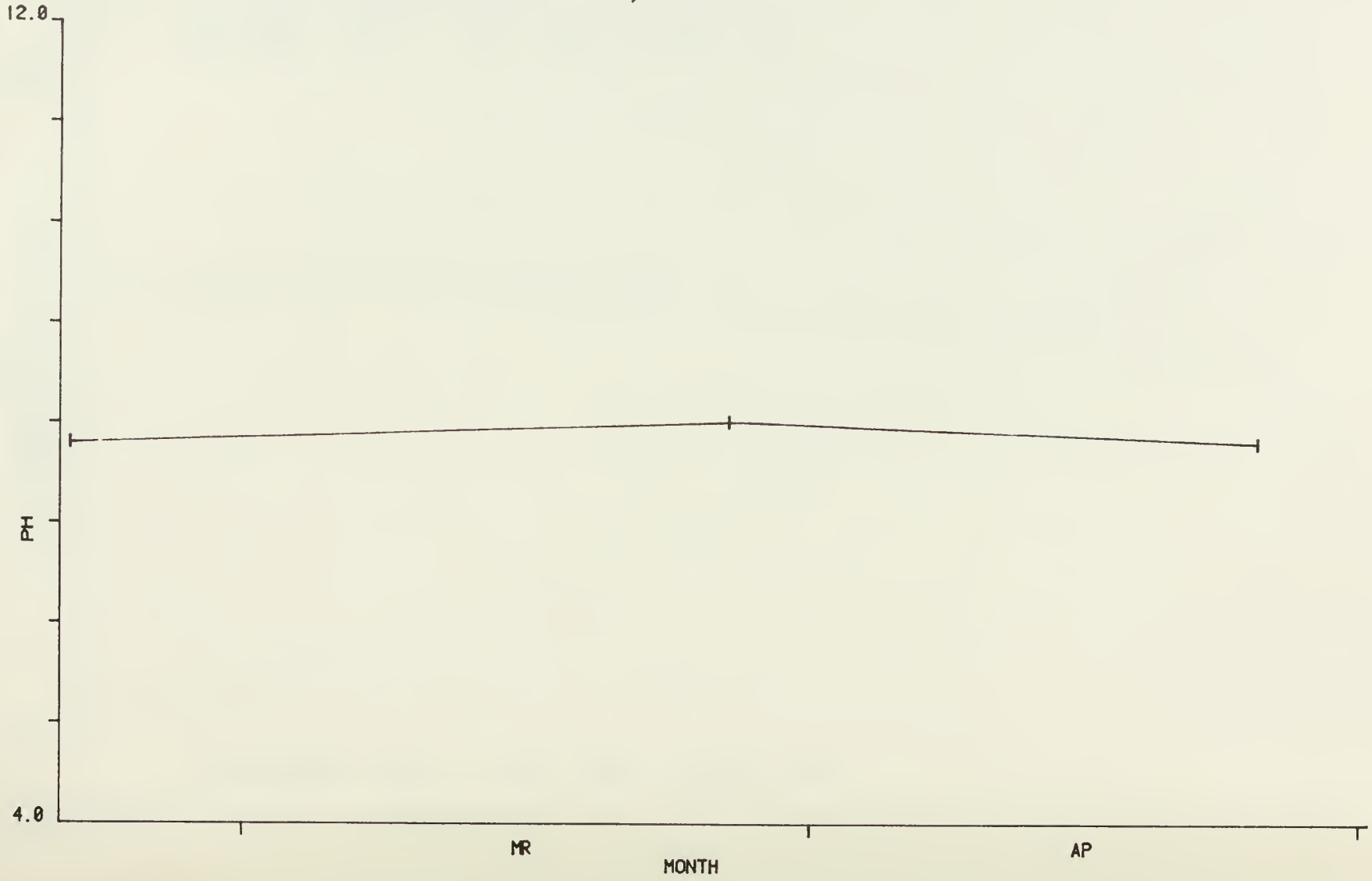


Figure 5-56. G-S 15L PH
DECEMBER 1978 — MAY 1979, TRACT C-A



SECTION 6
SPECIAL STUDIES

6.1 TOXICOLOGY

The purpose of the RBOSC toxicology program is to ascertain whether or not raw shale ore, processed shale, and shale oil may have toxic effects (MDP Environmental Monitoring Program Revision 5.2) The first phase of this program has been initiated with the shipment of raw shale ore samples, representing the total strata to be mixed and retorted during the MDP, to Standard Oil laboratory facilities in Naperville, Illinois. Chemical profiles will be conducted on these samples and results compared to data from recently completed American Petroleum Institute toxicology tests. Results will be reported in the year-end report. The results of these chemical tests will be used to finalize subsequent plans.

6.2 REVEGETATION

RBOSC continues to revegetate and/or temporarily stabilize disturbed areas. Seed obtained for this purpose during 1978 was stored on Tract C-a and utilized during May 1979. Germination ranged from 2 to 94 percent. Yellow sweetclover and Brome grass were the most successful species, each exhibiting germination totaling 94 percent. The poor germination of Indian ricegrass (2%) was not unexpected since this species often reaches maximum germination potential after several years of storage. However, scarification can enhance germination.

Table 6-1 Percentage Germination of Seed Obtained During 1978 and Utilized During May 1979

Seed Species	Percent Germination	
	3 days	9 days
Cicer milkvetch	8	62
Fourwing saltbush	14	18
Indian ricegrass	0	2
Lewis flax	12	94
Madrid yellow sweetclover	14	18
Manchar brome	60	94
Winterfat	58	58

6.3 SUBSIDENCE

The six month survey of the subsidence monuments (identified in Appendix 6-3) was initiated during the mid-year reporting period. Methods used for detection of subsidence monument movement were described in Section 7.3 of the MDP Environmental Program - Revision 5.2. No movement of any of the surveyed monuments could be detected. Monument D-12 was removed during clearing of the scrubber pond area. Complete analyses of the subsidence monuments survey will be reported in the year-end report.

6.4 SAGE GROUSE

The sage grouse is an important upland game bird in the Piceance Basin. The CDOW relies upon annual counts of sage grouse during the time of courtship for a population estimate. Sage grouse courtship occurs in early spring when males congregate on historic strutting grounds (termed leks) where they display specific behavior to attract females. In April 1979 the RBOSC Wildlife Biologist counted grouse on three important leks near Tract C-a to provide this information for the CDOW. Table 6-2. shows the number of grouse counted at the three leks.

Table 6-2 Sage grouse counted at three leks near Tract C-a in April 1979

Lek	April 20	April 21	April 27	April 29
Wolf Ridge	10 males 5 females		8 males 11 females	
Airplane Ridge South		9 males 3 females		12 males 1 female
Airplane Ridge North		14 males 23 females		12 males 0 females

The two Airplane Ridge leks were on opposite slopes directly across the gulch from each other and were counted simultaneously. Birds on one lek could see and hear the birds on the other, and some birds periodically left one lek to fly across the gully to the other; especially just after dawn. Counts were made when the majority of the birds had settled on the leks.

Any additional counts that may be done in subsequent years will be reported, and any trends in sage grouse numbers, as reflected in strutting ground counts in the Tract C-a area, will be documented.

6.5 RAW ORE LEACHATE SAMPLING

The objectives of sampling the raw ore leachate are to determine the effects of the raw ore on water passing through the storage pile. A leachate collector was installed in the run of mine storage pile and described in Section 6.4-H of the MDP Monitoring Program Revision 5.2. The U.S. Geological Survey sampled the accumulated water in the collector on April 26 and on May 31, 1979. Those samples are currently being analyzed by the Geological Survey and results will be discussed in the year-end report.

SECTION 7
ECOLOGICAL INTERACTIONS

During the reporting period, three major driving variables appeared to have influenced Tract C-a ecosystems. Although it is not possible to identify cause-effect relationships on the basis of these preliminary data, some interactions can be identified which should be studied in further detail. An expanding data base and continued evaluation of events are expected to result in identification of additional important interactions. Of the three driving variables to be discussed, one is a natural event and two relate to tract and gas-field development activities. They are:

- Snow cover and Spring runoff
- Temporary surface discharge of dewatering water
- Human activity on or adjacent to tract

Without question, the ecosystems were subjected to more influences than the three just identified. These factors have been singled out because they appear to be most closely related to identified changes and can be discussed with more confidence than can other factors. Continued evaluation of ecological interactions will ultimately result in expansion and/or refinement of this initial analysis.

The discussion provided herein is based on an incomplete data set for 1979 - several studies are to be completed in the summer-fall season. A more detailed discussion of ecological interactions will be provided annually in the year-end report.

7.1 SNOW COVER AND SPRING RUNOFF

The 1978-79 winter season was characterized by early snowfall, continued accumulation throughout the winter, and a late snow-melt. The first major snowfall occurred in November -- the last one of the season in April. The snow cover was continuous throughout most of this period, with accumulated depths in excess of four feet over much of the area. Lower than average temperatures (7 F lower than the average in 1978) were reported at our meteorological station and elsewhere throughout the area in 1979.

This deep, long-lasting snowcover was the most severe reported for the tract area since the RBOSC data accumulation program began in 1974. Similar conditions were reported from throughout the western part of the United States and in the Colorado mountains.

Immediate effects of this heavy, late-lying snowfall were exhibited as increased runoff at the Yellow Creek surface gaging station near the White River where 1979 flows (3 cfs) in March and April exceeded 1977 and 1978 flows (2 cfs) for the same period. However, despite the heavy snow accumulation, precipitation data at Site 1 near Tract C-a do not indicate an increase in total precipitation for the period. The extremely low temperatures apparently produced deep snows containing relatively little moisture.

During the same period, variations were noted in stream flows, substrate characteristics, sediment load, conductivity, alkalinity, and dissolved oxygen. These variations are probably related to natural precipitation events, however the variations from year to year are so great they obscure any trends that may be occurring. Qualitative observations of forb growth indicate greater abundance and cover in Spring 1979 than in previous springs (1975 - 1978). This may be related to late-lying snowpack allowing for increased available soil moisture at time of germination and growth. Productivity studies to be completed in September will provide additional data.

Increased snow depth during the winter forced deer off the tract to lower elevations in 1979 than in 1978. The depth of the snow apparently hampered movement, resulting in concentrated numbers of deer in some areas (south-facing slopes) and a reduction in numbers in other areas (north-facing slopes).

The Colorado Division of Wildlife reported an unusually high deer mortality (especially young-of-the-year) as a result of the severe winter conditions during 1978-79 in the winter range (P. Olson, CDOW, personal communication). As indicated earlier, deer were forced off Tract C-a as snow depths increased. No winter-killed deer were found on tract and only one carcass was found near the study area (in the Yellow Creek drainage).

The low number of deer wintering on tract was evidenced by relatively low browse use when compared to 1977-78 data. For example, pinyon-juniper habitat utilization in 1978-79 was 15 percent compared to 31 percent in 1977-78.

7.2 TEMPORARY SURFACE DISCHARGE OF DEWATERING WATER

During the reporting period, a series of tests were conducted in an effort to finalize a mine dewatering system. This resulted in the temporary discharge of upper aquifer water, removed from dewatering wells and mine inflow, to surface drainages on and off tract. Flows up to 4.5 cfs were recorded at the Corral Gulch gaging station during these discharges. This represents an increased annual runoff over previous years.

Stations downgradient exhibited the effects of this discharge with variations in water quality and physical parameters. However, variations at up-gradient stations were also experienced indicating that natural variations may obscure development-induced variations and may be of equal or greater importance.

Stream channel erosion data indicated that substantial down-cutting of the stream bed and sedimentation has occurred as a result of increased (dewatering) flows. This process is similar to natural weathering that results during intensive rain-fall events and has probably affected the aquatic habitat in a similar way.

Aquatic biota at Stations 13 and 14, near the point-discharge, continued to exhibit variation. Total cell densities for both stations were up from 1978, perhaps in response to warmer water temperatures as a result of discharge. Total cell densities were lower at the Yellow Creek and White River Stations in 1979 than in previous years. This may be related to colder water and increased scouring from the snow melt runoff.

Benthos density and diversity was uniformly lower in 1979 at all stations than recorded previously. Many factors may be involved, but the uniform occurrence indicates it may not be tract-development limited.

The presence of open water during the winter when normally little or no surface water is available attracted feral horses to Corral Gulch.

Digestion of roughage available during the winter is facilitated by ample water.

Migratory waterfowl were frequently observed using the habitat created by the warm discharge.

The discharge of water into Corral Gulch has resulted in increased soil moisture in the lower reaches of the gulch. This has apparently resulted in the loss of a small area of sagebrush along the drainage. Plant species more suitable to mesic conditions are invading this area.

7.3 HUMAN ACTIVITY ON OR ADJACENT TO THE TRACT

Oil Shale development and natural gas exploration on and near the tract has resulted in increased human activity. Increased road traffic has resulted in wildlife losses along many roads in the area. These wildlife losses are small compared to the natural winter mortality.

The heavy road traffic along County Road 24 into Tract C-a did not adversely affect the nesting activity of a golden eagle which successfuly fledged a young eaglet from a nest immediately adjacent to the road on July 4, 1979.

The population expansion of the area and improved accessability of the tract has increased recreational use of the area. This trend is expected to continue. The potential effects of this increased use will be evaluated as data become available.

SECTION 8
SUMMARY

Air quality and meteorological data were collected during the six-month reporting period. No unusual events or exceedances of National Ambient Air Quality Standards occurred. All of the air quality parameters were below the threshold of detection most of the time, with the exception of ozone and particulates. No NAAQS were violated during the study period. Ozone concentrations ranged from 0.029 to 0.071 ppm at Site 1, and from 0.008 to 0.070 ppm at Site 3. Particulate concentrations ranged from 1 to 34 ug/m^3 at the two sites measuring the ambient particulate level (Sites 1 and 2) and from 3 to 94 ug/m^3 at the site located in Corral Gulch (Site 3), which is often downwind of tract activities. These values are similar to those found in the 1977-78 mid-year report (MDP Monitoring Report 2). The higher particulate concentrations at Site 3 are somewhat biased in that the main tract access road (a dirt road) is also located within the gulch, approximately 100 yards from the hi-volume sampler, and the data therefore include fugitive dust from the access road.

No significant changes have been detected in the meteorological data collected during the six-month data period.

A Spring visibility study using both the traditional photometric method and a telephotometer to measure visual range has been initiated but was not completed during this reporting period.

Two noise surveys were taken during the reporting period. During the February survey, sound level averages on the tract ranged from 22 to 44 dBA, except near the main construction area (adjacent to headframe) which averaged 83 dBA. During the May survey, sound level averages ranged from 26 to 48 dBA, except an average of 78 dBA near the main construction area.

The components of the Terrestrial Monitoring Program examined during the reporting period were browse condition and utilization, mule deer density, mule deer road kills and feral horse abundance. Results from these studies are similar to those of previous sampling periods.

Browse utilization studies indicate the average percent utilization of browse species ranged from 4 percent in the upland sagebrush to 15 percent in the pinyon-juniper vegetation type. Utilization in both of these vegetation types decreased from that experienced in 1978 whereas use in the mixed brush type increased slightly. Lower use in the sagebrush and pinyon-juniper vegetation types is consistent with the evidence that the harsh winter caused deer to migrate off tract and use habitats at lower elevation.

Browse condition ratings for mixed brush, upland sagebrush and pinyon-juniper vegetation types were similar to those present during the 1978 sampling period.

Based upon the number of pellet groups counted, mule deer use of the Tract C-a area was somewhat lower this winter than the winter of 1977-1978. An average use of 38.1 deer per square mile was found for 1978-79 as compared to an average of 44.7 deer per square mile for 1977-78. This reduced use probably can be attributed to increased snow accumulation which pushed the deer to lower elevations off the study area.

Nine deer killed by collisions with vehicles were found along County Road 24 during the reporting period. Deer were very abundant along this road during the study period, and the number of road kills is low considering the heavy traffic and poor road conditions during that time.

A total of 99 feral horses in 21 bands was counted in the study area during the winter aerial horse count. This density of horses is comparable to that estimated in the study area for the previous winter.

The physical parameters measured at each aquatic sampling station in April 1979 were within the range of previous years except for increased volume of water at all stations and an increase in conductivity and alkalinity and decrease in dissolved oxygen and pH at Station 14.

The water quality parameters analysed for the sampling stations on the White River changed very little from baseline conditions. No significant difference was found between the water quality above and that below the confluence with Yellow Creek.

Periphyton densities and biomass were generally lower at Yellow Creek and White River aquatic sampling stations during April 1979 than in previous April samples. This may be accounted for in large part, by the increased volume of water as a result of both dewatering and spring snowmelt observed at all sites and a concomitant decrease in the size of periphyton communities caused by scouring. Densities of periphyton at Stations 13 and 14 were higher in 1979 than in 1978.

Benthos samples showed a decrease in the number of taxa at most stations and a decrease in density at all stations from previous April data.

Monthly flows for the first half of the water year 1979, when compared with the flows of water years 1975-1978, show that all reporting stations except Yellow Creek near the White River had flow patterns similar to those recorded in earlier water years. However, the magnitude of flows in Corral Gulch East was higher because of surface discharge from mine dewatering activities. The reduced flow during October through February at the Yellow Creek station was probably related to lower than average temperatures throughout the winter of 1978-1979, which caused snow to accumulate rather than melt.

Water year 1977 showed the effects of the drought at all the stations except Dry Fork, which did not suffer a reduction in runoff until 1978. The 1978 increase in runoff at Corral Gulch West and Box Elder Gulch stations represented a return to more normal flows. The Corral Gulch East gaging station, downstream of the dewatering activities, exhibited an increase in annual runoff in 1978 and the first seven months of water year 1979. This increase in total runoff was caused by the shut down of the injection well system in late February 1979 for testing purposes and the subsequent discharge of all water produced from dewatering into

Corral Gulch. Increased flows to date represent a 60 percent increase in runoff as a result of mine dewatering.

Statistical tests for surface gaging station water quality data resulted in identification of 11 chemical or physical constituents that were significantly different from baseline values. These differences are probably related to a number of factors including natural variation and mine dewatering discharges.

Data for springs and seeps were similar to baseline values except at Spring 14 in which conductivity was somewhat higher as a result of stagnation.

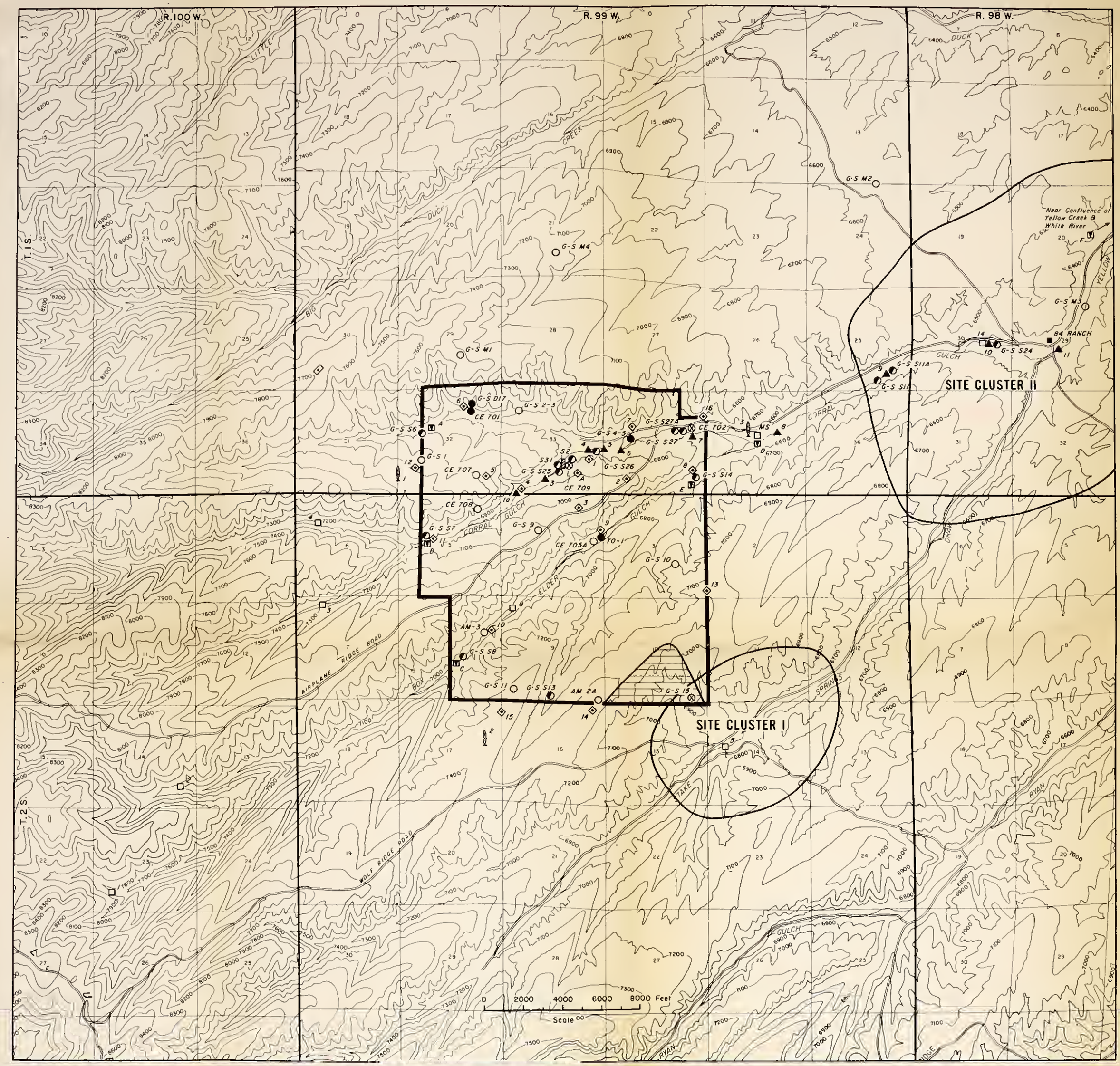
Water level, temperature, conductivity and pH of alluvial monitor holes appeared to have responded quite predictably to oil shale operations and, with certain exceptions values are within the ranges established during the baseline period. The greatest change in any one of these parameters was the rise in water level in G-S S11 of about 20 feet in response to the dewatering program discharges.

Special statistical tests (F & t) using the six-month water quality data set revealed that several alluvial constituents were significantly different from baseline. Control Stations G-S S7 and G-S S8, upgradient from tract activities, are not likely to have been affected by development. However significant differences between baseline values and MDP values were measured at these stations. Except for magnesium and potassium in G-S S24, all other parameter failures in G-S S11 and G-S S24 (treatment sites) were matched by similar F-test failures in the control stations (G-S S7 and G-S S8). Natural variation and possibly the lack of seasonal compatibility may explain the difference from baseline data.

Water level data in upper aquifer holes AM-3, G-S M2, G-S M3, and G-S 15 lower showed little or no effects of dewatering or reinjection during the reporting period. Holes G-S M1 and G-S M4 showed definite correlations with dewatering and reinjection, and G-S 15 Upper was apparently affected by dewatering, but not reinjection.

Statistical analysis of water quality data revealed significant differences from baseline for 14 constituents. Many of these differences are related to natural variation; others may be the result of dewatering effects.

The statistical analyses of data collected during the December 1978 through May 1979 reporting period has shown that a large number of constituents exhibit significant differences from baseline. However, these differences do not necessarily represent a development-related impact since control stations were affected as often as were treatment stations.



Legend

- SPRING OR SEEP
- STREAM GAGE
- MONITORING WELL IN ALLUVIAL AQUIFER
- MONITORING WELL IN UPPER AQUIFER
- MONITORING WELL IN UPPER & LOWER AQUIFER
- MONITORING WELL IN LOWER AQUIFER
- EROSION - SEDIMENTATION SITE
- ENVIRONMENTAL SOUND MONITORING SITE
- MINE DEWATERING FLUME
- O.A. MUNSON PIPEYARD
- METEOROLOGICAL & AIR QUALITY MONITORING SITE
- PROTECTED HISTORIC REGISTER SITE
- SITE CLUSTER - AREA OF ARCHAEOLOGICAL SIGNIFICANCE

DATE	REVISIONS
8/7/79	RREAD-ISD-004 Rev. 0.0.

Rio Blanco Oil Shale Company
RIO BLANCO COUNTY, COLORADO

ENVIRONMENTAL MONITORING SITES
MAP 1 - PHYSICAL

DRAWN BY JDJ	SCALE 1" = 2000'	FIGURE E-159A
DESIGN BY	DATE 8/7/79	
APPROVED BY RG & WJC		

FILE J-10

R. 100 W.

R. 99 W.

R. 98 W.

T. 1 S.

T. 2 S.

SITE CLUSTER II

SITE CLUSTER I

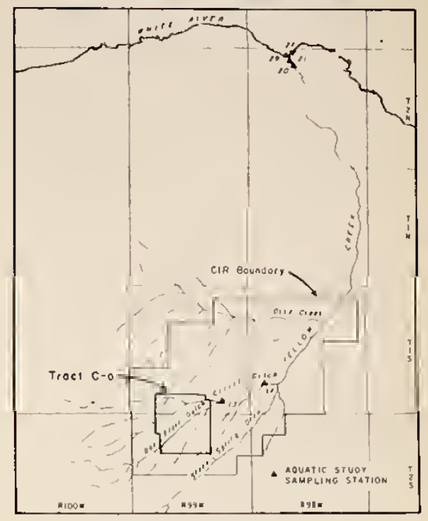
Inset Map A

Inset Map 'B'

0 2000 4000 6000 8000 Feet

Scale

Regional Map Showing Aquatic Studies Sampling Stations

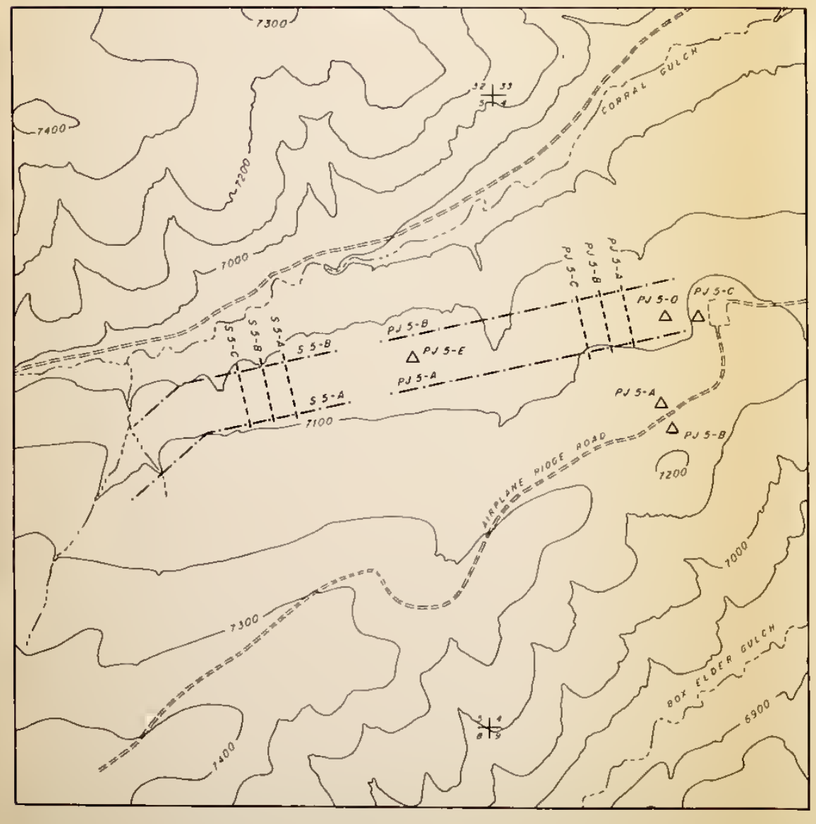


N

Legend

- 1979 COLOR INFRARED (CIR) PHOTOGRAPHY BOUNDARY - SEE REGIONAL MAP
- R1 EXPERIMENTAL REVEGETION PLOT
- 37 RANGE - BROWSE, PRODUCTIVITY & UTILIZATION STUDY SITE
- 9-30 MULE DEER PELLET GROUP TRANSECT
- PJ 5-A PHYTOSOCIOLOGICAL STUDY TRANSECT (PJ = PINYON/JUNIPER) - SEE INSET MAPS
- PJ 5-B AVIFAUNA TRANSECT (PJ = PINYON/JUNIPER, S = SAGEBRUSH) - SEE INSET MAPS
- PJ 5-C SMALL ANIMAL TRAPLINE (PJ = PINYON/JUNIPER, S = SAGEBRUSH) - SEE INSET MAPS
- D.A. MUNSON PIPEYARD
- PROTECTED HISTORIC REGISTER SITE
- SITE CLUSTER - AREA OF ARCHAEOLOGICAL SIGNIFICANCE

Inset Map 'A'



Inset Map 'B'

0 1000 2000 Feet

Scale

DATE	REVISIONS
8/3/83	ABEAD-180-005 Rev 0.0

Rio Blanco Oil Shale Company
RIO BLANCO COUNTY COLORADO

ENVIRONMENTAL MONITORING SITES
MAP 2 - ECOLOGICAL

DRAWN BY JDJ	APPROVED BY WJC & DAB	FIGURE
	DATE 8/3/83	E-158A

Form 1279-3
(June 1984)

BORROWE

IN 859 .L64 R56 Dec
May 79 v.
Modular development
monitoring report

DATE LOANED	BORROWER

USDI – BLM